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ANNALS *of* SURGERY

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THE CHLORINE ANTISEPTICS IN CIVIL HOSPITAL USE*

BY JOHN A. HARTWELL, M.D.
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OUR conclusions after four months' intensive study at Bellevue Hospital with the chlorine antiseptics are:

1. The establishment of the Carrel-Dakin technic presents no undue difficulty.

2. The results obtained in the military hospitals abroad can be duplicated in general civil hospitals in dealing with traumatic cases.

3. These antiseptics are not as efficient in controlling spontaneous infections, *i.e.*, those not directly due to trauma. They are not as valuable in burns as other forms of treatment.

4. Reasonable care prevents skin burns in all circumstances.

5. Dichloramine-T in either chlorinated eucalyptol or chlorcosane—the chlorinated paraffin oil—is not a completely efficient substitute for the sodium hypochlorite solution.

1. The inauguration of this work at Bellevue Hospital was undertaken on the Cornell Division late in October. The College provided one nurse who had taken a course at the Rockefeller War Hospital, and also a laboratory worker to do the routine bacteriological work. Later, when we were asked by the Surgeon General's Office to undertake the teaching of Medical Reserve Officers, Captain E. F. Butler, who had been on the staff of the same hospital, was detailed to assist in this work. No other member of either the surgical staff or the nursing staff had any but a theoretical knowledge of the subject, except the writer, who had had a limited experience by operating upon and following a few cases at the War Hospital. The traumatic cases and all suppurating cases were taken out of the general service and assigned to the care of this small staff. The house staff and the regular nursing staff at first only help incidentally.

The impetus given the work by placing it on a military basis for teaching purposes was very great. Our first concern was to assemble the necessary supplies. This was entrusted to Captain Butler and Dr. Dudley, and when the ordinary routine of hospital requisition was too slow, the College stepped in and procured the supplies direct. The making of the hypochlorite

* Read before the New York Surgical Society on March 13, 1918.

solution was entrusted to Dr. Stanley Benedict, of the Department of Chemistry at the College. The Phipps Institute, in Philadelphia, furnished us with our early supply of Dichloramine-T and chlorinated eucalyptol. When, later, Doctors Dakin and Dunham had perfected the chlorcosane, these preparations were procured from commercial houses, as was the chlorasine from the start.

The preliminary preparations consumed less than one week. Suitable cases were then selected and placed under the care of the special staff of two surgeons, one nurse and the laboratory worker. As mentioned above, the regular hospital organization was only used incidentally in the general care of the patients, the only specific duty of the nurses being to see that the requisite flushing of the tubes was given at the stated intervals. In addition to this the head nurse in each ward was usually present at dressings in order to receive instruction and render the assistance ordinarily assumed by the nurse in charge. The members of the house staff were not at first included in the organization, as it was desired to master the details of the technic before entrusting it to inexperienced surgical judgment.

Much of our time had to be devoted to teaching the Medical Officers, so that not more than two to three hours daily could be charged to the actual care of the patients, who at most times numbered twenty-five to thirty. With the arrangements above outlined, we considered that we had the methods in satisfactory working order at the end of one month. The head nurses were gradually worked into the organization, and by this time had become proficient in the details. The routine care of the patients occupied no more time or assistance than by the older methods of treatment. After another month a junior member of the house staff was admitted into the organization, and at the end of two weeks was entirely competent to handle all the less complicated cases with the aid of the head nurse only.

The final result, after four months, is a perfectly running machine which operates with no more difficulty than is experienced in the running of any hospital organization where the service is heavy and rapidly changing, and where much attention is paid to teaching. The only difficulties encountered were in keeping our supplies always up to the standard and having the dressing carriages properly equipped. This arose, not from any inherent difficulties, but from a willingness to " make do " with whatever is at hand, rather than to foresee and prepare. Insistence on detail overcame this, and it was not long before everything was at hand when needed.

The methods employed are thus given in order to show that with proper organization and a willingness to follow the details as worked out by Carrel there is no reason to prevent the application of the Carrel-Dakin technic in any well managed hospital service. It would not have been so easily accomplished with us without the aid of Captain Butler and the special nurse, Miss Gorman, because previous practical experience would have been lacking. This lack, however, would only have delayed the consummation of our plan, because the literature gives all needed information and daily experience overcomes the difficulties. We relied explicitly upon the descrip-

tions given by Carrel and accepted without question his methods, making no attempt to either improve them, modify them or substitute short cuts. Our desire was to test the question by exact duplication.

2. The statement that our results duplicate those reported from the war zone is, of course, based upon a comparatively limited number of cases. These included compound fractures, traumatic amputations and severe lacerations of the soft tissues. They were received into the hospital in all three stages, *i.e.*, contaminated within the first six or ten hours after injury; infected after six or ten hours, up to twenty-four hours, and suppurating after twenty-four hours to three or four days. In no case falling in the first stage, no matter how severe the injury, was there any subsequent suppuration. A compound T-fracture of the femur into the knee-joint, operated on eight hours after receiving the injury, was the most severe of this group. Recovery was slow, but took place without suppuration. The most difficult to cope with, however, were severe lacerations involving the dense tissues of the sole of the foot and the palm of the hand in laboring men. The unusual preponderance of fibrous tissue, subcutaneously, and the near coincident injury of the palmar and plantar fasciæ possessing low bacteriological resistance required the closest attention to prevent suppuration and the longest time to obtain surgical cleanliness.

In the second group—infection already being actively started—we were not able in all cases to control it without the suppurative stage developing. This was best illustrated by a border-line case between the first and second stages. The patient was admitted with his left arm nearly avulsed from the body, so far as the soft parts were concerned. There was also a badly comminuted compound fracture into the elbow-joint. The brachial artery was torn completely across at the profunda branch and many of the muscles of both the forearm and arm were literally shredded. He refused amputation. All lacerated tissue was removed, and thorough mechanical cleansing of the traumatized area accomplished. The tubes were placed and instillation of the hypochlorite solution carried out. Active evidence of infection was absent for nearly seventy-two hours. When the hand and forearm showed gangrene from lack of blood, the patient consented to amputation. During the period from evident gangrene until amputation was done, the infection developed rapidly and in the devitalized tissue was not in the least held in check by the treatment. It extended upward along the torn muscles of the shoulder girdle. Disarticulation of the shoulder was done, and tubes placed in all open spaces. The infection, which had now developed to the suppuration stage, was rapidly controlled and in one week the surfaces were all clean and healthy granulations covered them. There continued, however, a high bacterial count from the glenoid fossa. This could not be lowered by the most careful instillation of the hypochlorite solution.

Here was demonstrated a fact often seen, namely, that the bacterial count is the only true indication of proper progress. There was no active suppuration, and from a clinical standpoint surgical cleanliness seemed to

be present, but healing was slow. About two weeks later, under anæsthesia, the glenoid was exposed and the cartilage showed necrosis. The cartilage was removed and prompt lowering of the bacterial count resulted with rapid healing. The hypochlorite solution will not, in the presence of virulent infection, always prevent necrosis in such poorly nourished tissues as cartilage, fascial expansions, etc. This was found true in other cases.

Our success in treating the third stage, where active suppuration following trauma was established before the patient came under our care, was equally satisfactory with those in the earlier stages. There was, in this stage, no case with severe compound fractures or joint injuries, so that we were not put to any severe test. Two cases, however, gave potentially grave prognoses.

The first was a crushing laceration of the dorsum of the foot which had been sutured by the ambulance surgeon. The patient was received into the ward with a fulminating infection causing gangrene in the skin around the wound and extending well up the leg, and a high grade of lymphangitis and femoral adenitis. All acute symptoms were under control in forty-eight hours, and the granulating area was grafted successfully on about the fifteenth day.

The second case could give no account of his injury, but there had been a circular twisting violence of the muscles of the inner and anterior aspect of the thigh, with an extensive laceration of the skin. This, too, had been sutured, and was admitted with active suppuration. The muscles were torn from each other and from the femur; the vastus internus was torn almost completely across; the vessels were exposed, but not damaged; a severe suppuration had spread throughout the entire traumatized area. At operation the skin wound was enlarged, the hopelessly damaged muscles and effused blood removed and tubes placed in all parts. Suppuration was controlled in forty-eight to seventy-two hours and healing had begun.

A third case belonging to this general group was admitted from the erysipelas ward with extensive suppuration beneath the pericranium, involving practically the entire vault. The scalp tissues were so badly devitalized as to threaten gangrene. Incision and the instillation of the hypochlorite solution promptly controlled the suppuration and averted gangrene. It, however, did not prevent a recrudescence of the erysipelas. Final recovery was complete and the denuded ivory bone seen at first threw out granulations and the pericranium again became attached to it. The control of the suppuration and saving of the scalp may be credited to the hypochlorite solution, but the convalescence was very protracted.

3. The statement that spontaneous infection from within, not directly due to trauma, is not as efficiently controlled by the chlorine antiseptics is based upon observation of chronic osteomyelitis, suppurative tenosynovitis, empyema, abscess of the lung and abscess of the liver. In such conditions one is dealing with a very different pathological process, in that the infecting organisms are more or less deeply placed in the surrounding inflamma-

tory zone. The hypochlorite solution rapidly clears away the suppuration and digests off all necrotic tissue, but one cannot see that the deeper processes are more rapidly attacked than with simple efficient drainage and daily dressings. There were a large number of cases with advanced purulent tenosynovitis admitted to the service and the results in these were particularly disappointing. It is true that most of the cases doing badly were chronic alcoholics, with more or less advanced degenerative changes and correspondingly lowered resistance. The empyemata treated with the usual operative procedure and then washed periodically with the chlorazine solution, .5 per cent., by means of Carrel tubes placed in all parts of the cavity, did well, but the progress did not seem more rapid than by other methods of treatment. Our conclusion that the non-traumatic suppuration is not as effectively dealt with as the traumatic is not susceptible of actual proof, but it represents the opinion of all those observing the cases.

In burns we were unable to demonstrate that the chlorine antiseptics were of especial value. They were used in comparison with the paraffin treatment and the older forms of treatment. The hypochlorite solution causes too much pain to be practicable. The dichloramine-T failed to control the superficial suppuration, and it could not be seen that epithelization was unusually rapid. It has been fully demonstrated that the chlorine antiseptics are not bactericidal to the bacillus pyocyaneus, and burn infection is often contaminated with this organism.

4. In no instance were we troubled with skin irritation as the result of the use of the hypochlorite solution, except that in one or two cases a superficial irritation was caused when the solution found its way under a tightly applied retention dressing. The technic as described by Carrel for the prevention of burns was carefully adhered to. Much has been said of the difficulty and tediousness of carrying out this part of the procedure. Our experience does not substantiate this view. Vaseline gauze, if properly prepared, and the skin thoroughly dried, is applied with no difficulty, and is not unduly time consuming. In most instances, after the first three or four days, the vaseline gauze does not have to be changed oftener than every second day, and sometimes not so frequently.

As stated above, the solution used by us was prepared in the college laboratory by Mr. Emil Osterberg, under the direction of Dr. Stanley Benedict, professor of chemistry. We believe that this fact had very much to do with the success of our work and the absence of irritating effects. This solution would remain at the standard strength for several days, or even weeks, and its titration in the general supply, the irrigation jars and the tubes, practised at regular intervals, showed no deterioration and no change in its reaction. This is quite contrary to the experiences of those who have attempted to use Dakin's solution as made up in the hospital pharmacies. It is quite possible that a greater chemical skill is required to properly standardize the solution than is implied in the published description of its preparation. At any rate, the laboratory was able to furnish us solutions

which remained unchanged for a period of four weeks to four months, without any especial protection from light or other deteriorating conditions.

We are permitted to report that Doctor Benedict has perfected a modification of the preparation of Dakin's solution in which sodium chloride instead of bleaching powder is used. This method is far simpler than the older method, or that in which the chlorine gas is used, and results in all instances in a standard strength solution with a variation of not more than one-tenth of one per cent. A published description of this will appear in the near future.

5. The *Dichloramine-T* was used at first dissolved in chlorinated eucalyptol, and later in chlorcosane—a chlorinated paraffin oil. We were not able to demonstrate that these preparations were able to so completely control infection as the hypochlorite solution. Furthermore, the granulating surface resulting from their use was less healthy and less adapted to secondary suture or skin grafting than were the surfaces after the hypochlorite solution. In the use of the chlorcosane there was also a tendency for the heavy oil to prevent the advancing epithelium from the edges of a wound adhering to the granulations. It was not unusual to find a film of living epithelium extending out over the granulations for a distance of ½ cm. or more, without becoming attached to them. In doing grafting and secondary sutures it was found necessary to very carefully remove this oily film in order that adjacent surfaces would properly grow together.

We did not feel justified in attempting to use the dichloramine-T spray in extensive complicated wounds of the soft parts or in compound fractures. This attitude was taken because it seemed impossible to procure one of the essentials of antiseptic treatment, namely, contact. With a little practice Carrel tubes can be so placed that one is practically certain of bringing the Dakin's solution into recurrent contact with every portion of any wound. This we were not able to see any method of accomplishing with the dichloramine-T in deep lacerations extending into the muscles, bones and joints. It is only fair to say, therefore, we possibly did not give the remedy as complete a trial as we did the Dakin's solution, and with further experience we may feel more willing to use it in this type of case. In one such case, a severe suppuration in the muscles of the calf occurring in a diabetic patient, the Dakin's solution and the dichloramine-T were both used over different periods, as was also done in a widely opened chronic osteomyelitis of the tibia. In neither of these cases was it possible to keep the bacterial count down to a point of surgical cleanliness with the dichloramine-T, and its use had to be abandoned in favor of the Dakin solution.

In summarizing we feel that our four months' experience has satisfactorily demonstrated the practicability and the advantages of using the Carrel-Dakin treatment in those civil hospitals where a considerable number of traumatic cases are treated. It is interesting to note that its practicability and advantages have been accepted by the Surgeons General of the British Army. Sir Anthony Bowlby ("The Development of British Surgery at

the Front," *British Medical Journal,* June 2, 1917) and Sir George H. Makins ("The Development of British Surgery in the Hospitals on the Lines of Communication in France," *British Medical Journal,* June 16, 1917) state emphatically that this treatment has demonstrated its superiority over others. It is now used in the British Casualty Clearing Stations, and provision has been made for its continuance on the hospital trains and the hospital ships, so that the wounded receive the benefit of it continuously until received into the base hospitals. This, in view of the earlier skepticism of the British, is strong testimony in its favor.

In those civil hospitals where a traumatic service is not an important part of the hospital work, it is doubtful whether the inauguration of this treatment will meet with great success, for the reason that the call for its use will not be frequent enough to make it an established routine. Without this, it probably would be no more effectively applied than is any other special form of treatment which is only occasionally demanded in a general hospital service, and if ineffectively applied it cannot be expected that satisfactory results will follow.

BISMUTH PASTE IN WAR SURGERY *

ITS USE IN COMBINATION WITH THE SKIN SLIDING OPERATIONS FOR CHRONIC SUPPURATIONS AND LUNG ABSCESS

By Emil G. Beck, M.D.
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Military surgeons serving at the front inform us that there is a rapid accumulation of chronic suppurative cases in Europe, although everything possible is done on the battlefield and in the First Aid stations to prevent their occurrence. Guillot and Woimant [1] who recently published their experiences with infected fractures in the French base hospitals state that probably 50 per cent. of all fractures of the thigh still suppurate after ten months of treatment.

Disinfection of a wound an hour after the injury by an orderly is more efficient than the most scientific treatment two or three days later, if such primary disinfection is not practised. The principal factors in the prevention of chronic suppuration now considered are: The prompt and complete excision of the infected area, as practised now in the field hospitals, and Carrel's ingenious method of flushing the wounds with hypertonic solutions. If it were not for these, the hospitals of Europe would be unable to care for the enormous number of suppurative cases which would accumulate. Besides, the economic waste due to loss of men, to invalidism, and to dressings would be most disastrous. It is, therefore, very timely and imperative that we prepare ourselves to receive and to treat these cases of chronic suppurations with the most efficient methods at our disposal.

With this aim in view, I desire to offer some suggestions in the treatment of those cases in which the methods of prevention have not been effective and persisted in discharging pus. These suggestions are based on an experience gained in treating about 2000 chronic suppurative cases. Although most of these were chronic discharging sinuses resulting from tubercular bones and joints or post-operative suppurations, the treatment here outlined will be quite as effective in the chronic suppurations produced by war injuries, since the late conditions in both instances are nearly identical.

It has always been a problem how to deal with this class of cases. Only during the past ten years has any real progress been made. Until then, almost every form of treatment which had been tried was found lacking. Cases were repeatedly operated, then irrigated by various solutions, such as permanganate of potash, weak solutions of iodine, silver nitrate, etc., and after these procedures have all been tried alternately and in time found inefficient, the patients usually became reconciled to daily dressing, giving up all hope of ever being cured.

* Read before the Academy of Medicine, Cincinnati, March 11, 1918.

[1] Surgery, Gynecology and Obstetrics, November, 1917, p. 507.

Ten years ago we (my brothers and I) introduced a new method of treatment of this class of cases; namely, the injection of "*bismuth paste.*"[2] It is unnecessary here to repeat in detail the theoretical aspects of this method. By this time the bismuth paste method of treating chronic suppurations is well known and its efficacy recognized. After ten years' use in almost all parts of the world, it has retained its place and is now employed more extensively than ever. Reports in the literature indicate that approximately three out of four cases of the very old neglected suppurative sinuses may be cured by this simple procedure.

Many surgeons and physicians have the impression that the use of bismuth paste is confined to tuberculous sinuses following bone and joint affections. I wish to correct this false impression by stating that the bismuth paste has been applied successfully in the treatment of all chronic suppuration from whatever source in practically any part of the body. The postoperative fistula of the abdomen, the nasal accessory sinuses when affected with chronic suppurative disease, and even fecal and genito-urinary fistulæ have yielded most readily to this form of treatment. But the most favorable results in my experience have been obtained in infected wounds after crushing injuries of bone and soft tissues.

This experience leads me to advise its use in war surgery, where the majority of wounds are infected before they reach the base hospital. I was recently informed by Doctor Carrel that the method was employed at the French base hospital at Compiegn in 1916 with satisfactory results, with material and instruments I sent him at that time. Doctor Richter, in charge of one of the Red Cross units which for a time worked in a German base hospital, also used this method of injecting suppurative wounds resulting from shrapnel, gunshot and bayonet, and reported most satisfactory results.

During the past year there appeared in *The London Lancet* a number of articles on the use of B. I. P. P.,[3] the first article being written by Rutherford Morrison,[4] August 12, 1916. His formula differs from mine in that he has added iodoform, and, instead of using vaseline, he uses liquid paraffin. The results obtained by him and by others who have used this paste indicate that the floodings of sinuses with bismuth mixtures of various combinations is a most effective treatment of infected wounds. I have, as yet, had no experience with the formula which Morrison advocates, but since he applies it in the acute forms of suppuration, it may have some advantage in this class of cases.

The principal factor in obtaining good results with any of these flooding mixtures is "*correct technic,*" and since experience in their application

[2] Beck, E. G.: A New Method of Treatment of Sinuses and Fistulæ. Journal of the American Medical Association, March 14, 1908.

[3] Which is an abbreviation for bismuth, iodoform, paraffin paste.

[4] Rutherford Morrison: Treatment of Suppurating, Infected War Wounds. The Lancet, August 12, 1916.

teaches us many points, I believe it might be of value to those who use it, as well as to those who contemplate using it, to have pointed out to them technical errors which are usually committed, leading to poor results, and then to have an outline of the practical application of the bismuth paste in war surgery.

Technical errors usually committed:

1. The method is applied indiscriminately, without control by radiograms.

2. The mixture, when injected, is not sufficiently liquefied to fill all the sinuses and suppurating cavities.

3. The bismuth is applied in cases in which either a sequestrum or infected foreign body is at the bottom of the trouble.

4. The injections are often kept up after the wound is sterilized and thus no chance is given for healing.

5. The instruments used are often improvised and unsuitable.

6. The bismuth mixture is very often spoiled by the accidental admixture of a few drops of water. (Syringes should be perfectly dry when used.)

The following technic should be followed as closely as possible:

1. Preliminary to the treatment a set of stereoröntgenograms of the affected region is taken, to make sure that there are no foreign bodies or sequestra present. If such were present, they might be overlooked after the bismuth had been injected, because the shadows produced by the bismuth would obliterate the shadow of the foreign body.

2. Bacteriologic examination of the secretion is the next step. Smear preparations, cultures, and, in some instances, inoculation of guinea-pigs are made.

3. The wound is now ready for injection. The skin surrounding the wound is washed with alcohol and the tip of the glass syringe, which has been filled with the liquefied paste, is placed firmly against one of the drainage openings connecting with the wound, and the paste slowly but firmly forced into its channel until it is seen to escape from the nearest opening. Then the finger is quickly placed against this opening to prevent the escape of the paste, and the injection is continued. If there are many openings, an assistant must occlude all of them with his fingers during the injection, in order to be certain that all the branches of the sinuses have been filled. If there is merely a large suppurating cavity, it may be packed with gauze strips which are saturated with liquefied paste, and the injections may be carried on when the cavity has contracted down to a sinus.

4. After the injection another set of stereoscopic röntgenograms is taken, which give a clear picture of the entire network of sinus tracts and sometimes are the means of tracing the path to the focus from which the disease originated.

5. A sterile bandage is then applied and the patient put to bed for a few hours or a few days, depending on the severity of the case. In subsequent treatments the patients are usually allowed to walk about immediately after the injection.

6. The first dressing is done the following day. If the discharge which before the injection was creamy or profuse, has changed to a serous consistency, it is to be regarded as a favorable sign, and a microscopic examination will usually prove it to have become sterile. If the discharge is sterile, the sinuses need not be reinjected unless they later become reinfected. It is not intended that the paste remain in the sinuses. It will gradually exude, and within a week only traces may be found by fluoroscopic examination or by röntgenogram.

7. Should the discharge persist and remain purulent, the injections should be repeated at intervals of from five to six days for a reasonable length of time (from four to six weeks), and if after this period there is no appreciable improvement, one must search for the cause. A sequestrum may be present, or the focus of the suppuration be inaccessible to the paste, as, for instance, in the cancellous structure of long bones. In such cases, either the foreign body must be removed, or, as the case may be, the infected cancellous structure of bone curetted, and the bismuth injections resumed.

I illustrate herewith the instruments which are commonly used in my work (see Fig. 1).

I am convinced that with the proper application of this method we will be able to cure at least 75 per cent. of all the chronic suppuratives. For the remaining 25 per cent., which are usually considered practically hopeless, I shall suggest a surgical procedure which in my experience has been so effective as to justify our expectation of eventually being able to cure nearly all chronic suppurations.

In discussing the method in its application in special cases we shall divide the subject into two parts: (*a*) The treatment of *empyema and lung abscess* after prolonged drainage. (*b*) The treatment of *chronic suppurations* resulting from injuries in other parts of the body.

(A) EMPYEMA AND LUNG ABSCESS

After an infected wound in the chest has produced either a lung abscess or an empyema and has been properly drained, and has in spite of the most painstaking treatment failed to close, the problem becomes a difficult one. The patient, in the hope of final recovery, persists in dressing his chest wound once or twice a day, being well enough to perform some light work. Whenever his health suffers he becomes so discouraged that he is willing to submit to any operation which will either cure him or commit him to his grave. In this class of cases the bismuth paste has been found to be of the greatest value.

Doctor Ochsner, Chicago, reported to the American Surgical Association on June 4, 1909, 14 cases of empyema, all of which had been operated (two by Estlander's operation), with sinuses in all cases persisting nevertheless. He applied the bismuth paste in each of these cases, with the result that 12 cases healed completely and two were still under treatment at the time and very much improved. Others have reported equally good results. In my

own series of 110 cases, approximately 80 per cent. were cured by the bismuth injection treatment alone.

The procedure is as follows: Subsequent to a physical examination a stereoscopic röntgenogram of the entire chest (plate size 14 × 17) should first be taken.

After the pathological condition is ascertained and cultures of the discharge taken, the cavity is injected with a 10 per cent. bismuth-vaseline paste (bismuth subnitrate, 10.0; vaseline, 90.0).[5]

When the cavity or sinus is completely filled with this mixture, another set of stereoröntgenograms is taken. This set will illustrate the exact size of the cavity and its relation to the ribs and other structures in the chest. Whenever a communication with a bronchus exists, the patient will at once cough up the excess quantity of paste.[6]

The cavity may hold as much as 600 grammes, but from 100 to 200 is the average. See Fig. 2*a*, which gives a definite outline of the cavity filled with air before the injection, showing the thickened pleura covering the contracted lung, thus dividing the left chest into two almost equal sections.

The second röntgenogram (Fig. 2*b*) shows the cavity entirely filled with bismuth, and plainly defines the inner boundary of the cavity to be formed by the thickened pleura. The sizes and shapes of these cavities vary so much that there are no two cases alike. Sometimes we find a small globular sac communication with the outer chest wall by a long tortuous channel, and then again we find that there exists merely a long sinus without any cavity whatsoever. The stereoscopic effect permits us to estimate with considerable precision the depth of the cavity and its location.

The first injection does not always produce healing. In some cases repeated injections during several months are required, but these should be discontinued as soon as the discharge changes from a purulent to a serous character. Only when the discharge continues to be purulent should we consider radical procedures.

For illustration I shall cite just one case, which is a type most commonly encountered. Space prevents my illustrating more cases, and I refer the reader to my previous publications for further knowledge on this subject.

Empyema: Eighteen months' suppuration. Laborer, aged thirty-one, entered hospital November 17, 1917, with a profusely discharging sinus in the left anterior axillary line. Operation for empyema had been performed eighteen months previously and suppuration continued ever since. Treatment with various irrigations and injections, including paraffin oil, by his surgeon were of no avail.

[5] In former years I employed a mixture containing 30 per cent. bismuth subnitrate, but found that the above mixture produces equally good results and is not likely to cause bismuth absorption.

[6] A word of caution is here necessary: The patient should be warned not to take a deep inspiration during the injection. He is apt to inhale (through the existing opening of a bronchus on the infected side) some of the mixture and force it into the bronchus of the opposite side.

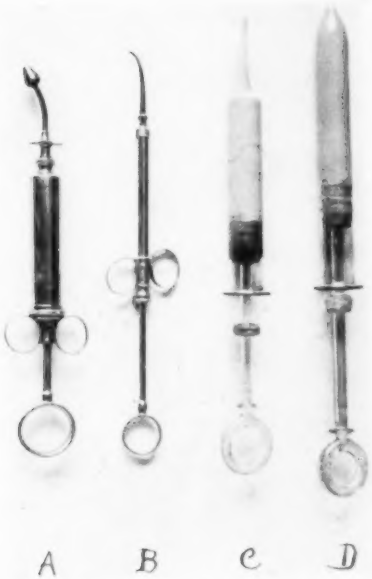

FIG. 1.—Instruments necessary for correct technic: *A*, metal syringe for small sinuses; *B*, metal syringe for stitch abscess; *C*, glass syringe for rectal work; *D*, glass syringe for all other work.

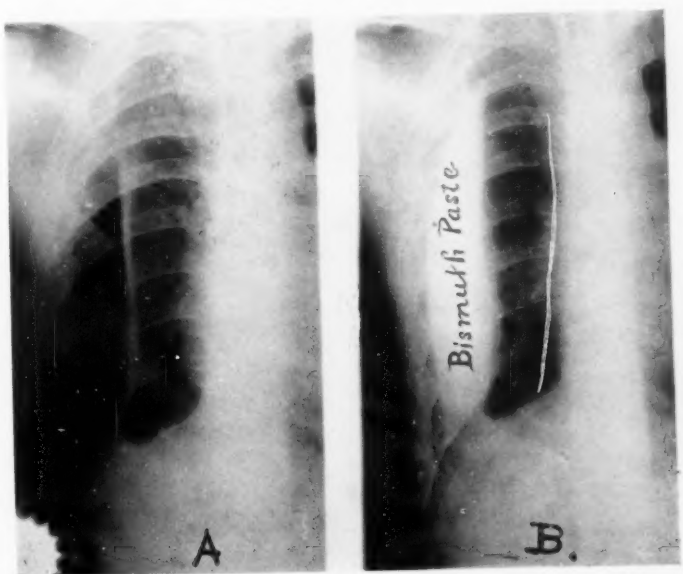

FIG. 2.—Empyema injected with bismuth paste. *A*, empty pleural cavity; *B*, cavity injected with bismuth paste. Note the thickened pleura dividing the lung from the empty space.

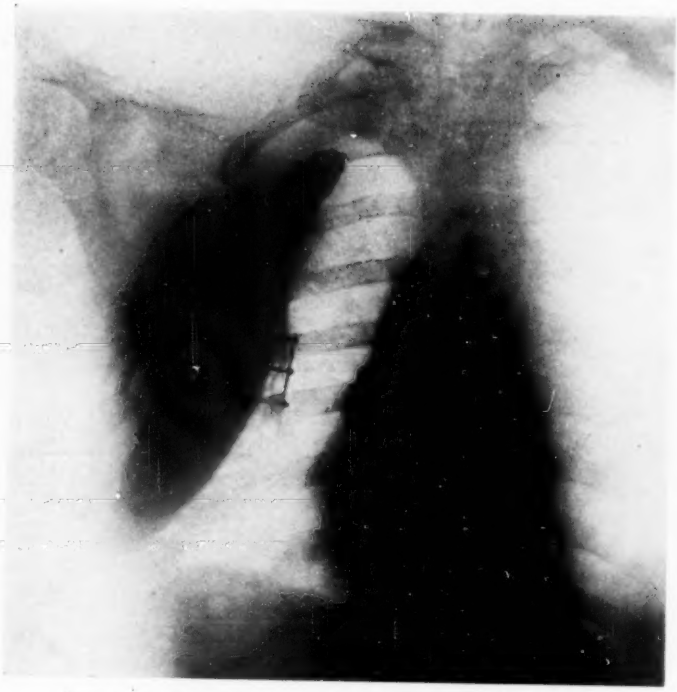

FIG. 3.—Lung abscess in upper lobe injected with bismuth paste.

An injection of six ounces of bismuth paste into the sinus filled the chronic empyema cavity which existed in the upper part of his chest (see Fig. 3).

The secretion, which was purulent and contained various types of organisms before the injection, was found to be serous and sterile twenty-four hours later. The sinus closed within four days and has remained so to date. Patient gained in general health and returned to his usual work.

We have tried to ascertain why some cases respond to the bismuth treatment and why others do not, and have come to the conclusion that whenever the cavity holds more than 200 grammes it will be less likely to heal by the bismuth paste injections. Cases which communicate with the bronchi are also more resistant than simple empyema.

Some cases heal shortly after the injection and remain closed for a year or two and the patient may be in good health, often gaining as much as thirty pounds, and then the sinus may reopen. The injections are then to be repeated. Closure usually follows for another year or two, and another relapse may follow at the end of that period. The patient often prefers to keep on treatment in this way, not being much inconvenienced and perfectly well in the intervals.

But there remains a small number, about one in five cases, which have no tendency whatever to heal under any form of treatment, and these require the most radical surgical procedure.

The methods in vogue in dealing with these refractory cases are known as the Estlander, the Schede operation, or the decortication of the lung. The patient who has to submit to one of these extensive surgical procedures is, of course, in a desperate situation. He is told that the operation causes a high mortality and that the surgeon cannot promise him an absolute cure. Aside from that, the surgeon must warn him of the prospect of a considerable deformity of his chest, whether he be cured or not.

Sutureless Skin Sliding Operation for Lung Abscess and Empyema.—During the past seven years I have employed a surgical procedure in these cases which I believe is less dangerous and quite as satisfactory as the Estlander or similar operations. Here I shall only make brief reference to this method, and refer those interested in this procedure to a publication in the *Journal of Surgery, Gynecology, and Obstetrics,* March, 1918.

The aim of this operation is to transform the abscess cavity into one lined with skin. To accomplish this the following procedure has been found effective:

Skin flaps, one to four in number, are made from the skin of the chest wall overlying the lung abscess or empyema. After the resection of a sufficient number of ribs over the lung abscess, which has first been localized by means of stereoröntgenograms, the abscess cavity is widely exposed, cleared of any contents, and the skin flaps are shifted into the depth of the cavity and kept in contact with the abscess wall by packing gauze tightly against the flaps. No suture material whatever is used to diminish the

size of the wound. In fact, the wound should be spread as far as possible. In forty-eight hours these flaps usually have become adherent to the abscess wall. The packing is removed, bismuth paste is injected, and the cavity repacked with gauze.

Epidermization will take place from the edges of the implanted flaps and in a reasonably short time the entire cavity will be lined with true skin, thus converting a fibrous suppurating sac into a dry cavity lined with skin, continuous with the skin of the chest wall.

In order to accelerate the epithelial growth from the skin edges, we have employed adhesive plaster strips, pasted in such a manner as to partly cover the edges of the true skin and of the granulating surface.

The denuded surfaces from which the skin flaps are taken are simply covered with gauze and these will gradually epidermize on the same principle as those of the flaps within the cavity.

In cases where one or more bronchi open into the lung abscess, the same may be closed by destroying the mucous membrane within the lumen of the bronchi by cautery, either at the time of operation or subsequently. This operation has been performed in seven cases, with very satisfactory results.

The logic of this surgical procedure consists in transforming the abscess cavity into a surface lined with skin. The cavity thus lined with epithelial covering will gradually diminish in size until the skin practically is outside of the cavity, the underlying tissues will gradually expand until the skin is pushed out to the surface of the body and there will be less deformity and a more satisfactory result in every way.

(B) CHRONIC SUPPURATIONS AND SINUSES DUE TO CRUSHING INJURIES AND GUNSHOT WOUNDS

Whenever the early treatment of these infected wounds has not been effective and chronic suppuration persists, there is either an infected foreign body or bone sequestrum at the bottom of the lesion, or the infection has penetrated into regions into which the disinfectant cannot penetrate or which cannot be reached by surgery. The traumatic cases have a tendency to spontaneous cure—first, because the patient's general health is usually much better, and, second, the infection is local and accessible to effective surgery, while those produced by chronic diseases have sinuses leading from inaccessible regions. The traumatic type for this reason also yields more readily to the treatment of injection by bismuth paste.

Guillot and Woimant [7] present a valuable contribution to the subject of early sterilization of infected wounds and late suppurations. They advocate first the Carrel-Dakin method of sterilization, sometimes followed by injections of different combinations of paste. They give preference to the bismuth paste, having observed no toxic effects and obtained good results. They advocate after sterilization of the wound the implantation of fat and suture of the wound. Those who have studied their reports and ob-

[7] Surgery, Gynecology and Obstetrics, November, 1917, p. 507.

servations and will compare them with those contained in this article will observe the essential difference to be as follows: *They advise the suture of the wounds, while I do not.* They use irrigation preceding the paste injection, while I omit all flushings. I do not advocate the suturing of the wound because this locks up the paste mixtures, which, after all, are foreign substances and may lead to absorption and poisonous effects. We have not practised the flushing of sinuses with watery solutions for many years and have obtained very good results without it. It should, therefore, be established by those who use flushings and the paste afterward whether the use of the paste alone would not accomplish as much.

As to the choice of the different pastes which are now being employed in war hospitals, I do not venture to dogmatize. I have now employed the bismuth-vaseline paste for ten years with gratifying results and have found no reason to employ new mixtures. This, however, does not preclude the possibility of an improvement, and I shall be pleased to adopt any other combination of paste as soon as I am convinced that it is superior to the bismuth paste.

The B. I. P. P. mixture advocated by Rutherford Morrison, of England, is said to produce very favorable results. I used the combination of iodoform and bismuth when I first introduced the method about ten years ago,[8] but on account of its odor, to which the patients objected, I had to discontinue it. I have found no difference in the results since its discontinuation. I would, however, warn against the closure of the wound after the iodoform or bismuth mixture has been injected. Iodoform is even more toxic than bismuth. Fortunately, we are able to avoid bismuth intoxication.

It is, of course, essential that sequestra should not be allowed to remain in bone cavities, otherwise the bismuth paste treatment will not be effective.

I consider the injection of bismuth for diagnostic purposes in these cases most essential, and at the same time enter a protest against the use of the probe as a diagnostic instrument. The probe is very misleading when we wish to ascertain the depth of sinuses or bone cavities. One needs only to glance at one of these radiograms in which the sinuses have been injected (Fig. 4) to convince himself that the use of the probe in ascertaining the course of the tract borders on the ridiculous. The tip of the probe may be resting in the nearest pocket or recess of the tract, and leave us under the impression that we have reached the bottom, whereas there may be a network of sinuses into which the probe can never be introduced. In fact, the sinus at times may be twice as long as the probe itself.

Curettage of the bony cavities without ocular inspection is likewise inefficient, especially if it is done blindly by introducing the curette through the sinus opening and scraping in all directions. Such a procedure is mere guesswork. No one can know whether he has reached all the diseased areas. Many times I have convinced myself of this by exposing the cavities which I had curetted and found that I had curetted in the direction of healthy bone and left the most diseased area untouched. Even exposure of

[8] Illinois Medical Journal, 1909.

the bone cavity and a very thorough curettage of every crevice under ocular inspection does not always prevent the recurrence of the suppuration. The customary procedure, for instance, of curetting the shaft of the femur, introducing a drain at one end and sewing the skin over the wound, will, in most instances, result in failure. A channel usually remains underneath the sutured skin and the suppuration soon returns.

I shall cite only four cases, which will suffice for illustration, although the method has been applied in practically every form of chronic suppuration in the body, including tuberculosis of the spine and all other joints.

Crushing injury of foot treated with bismuth paste. E. P., a man of twenty-two, while riding a motorcycle, was run over by a motor truck. The right foot was crushed completely by the heavy wheel (see Fig. 5). The heel having been torn away, it was replaced and gauze drains introduced. On account of the virulent type of infection, condition grew worse, the fever rose to 105°, so that an amputation was contemplated. Gradual improvement, however, took place and a profuse chronic suppuration from six different sinuses resulted, persisting for two months.

Injection of bismuth paste was then resorted to, as shown in Fig. 6. Within three days the purulent discharge became serous in character. From then on the condition improved rapidly and the sinuses began to close. Within two months the limb was entirely healed and gradually assumed normal shape. Patient is now able to walk without the use of a crutch (Fig. 7 *a, b, c*).

Infection of bone plates. Treatment with bismuth injections—subsequent skin flap operation. A young man of twenty sustained a fracture of his left fibula. There was no abrasion on the skin. One week later a surgeon performed an operation, splinting the fragments with two steel plates. The day following the operation the young man developed a most extreme chorea, so severe that it required two men to hold him in bed. A week later I saw him in this condition. On removing a part of the cast, we found the entire area of incision in a semigangrenous condition, the sutures having cut through the tissues and pus oozing from all parts of the œdematous and inflamed limb (see Fig. 8).

The bone plates were removed and the infected wound was treated with bismuth paste injections for two weeks. No irrigation was employed. Subsequently the remaining cavity was curetted and a skin flap about two and a half inches wide and four inches long was denuded from the edge and shifted into the depth of the wound. Gauze was packed against it so as to keep it in place for healing. Adhesion of skin flap took place and growth of skin from the side of the flap progressed rapidly (as seen in Fig. 9, taken four days after the operation). The denuded surfaces of muscle and connective tissue were treated by the adhesive plaster method and skin gradually covered the entire denuded surface as seen in Figs. 10 and 11. The chorea gradually disappeared, the patient gained thirty pounds and is now able to walk without a cane.

FIG. 4.—The sinus opening, apparently from hip-joint disease, proves to be tuberculosis of sacrum, ascertained by means of bismuth injection.

FIG. 5.—Crushing injury of foot, infected and drained in six places; bones crushed.

FIG. 6.—Radiogram of the foot after injection with bismuth paste.

FIG. 7a.—Sinuses closed after bismuth injections, but denuded surface still present.

FIG. 7b.—Perfect closure of all sinuses. Foot in extension.

FIG. 7c.—Foot in flexion.

FIG. 8.—Plated fracture of fibula, with secondary infection. Necrosis of skin and muscles.

FIG. 9.—Excision of necrosed bone, muscles and skin. Skin sliding operation.

FIG. 10.—Condition two weeks after operation by treatment of adhesive plaster for skin regeneration.

FIG. 11.—Complete closure four months after operation, with perfect function of leg.

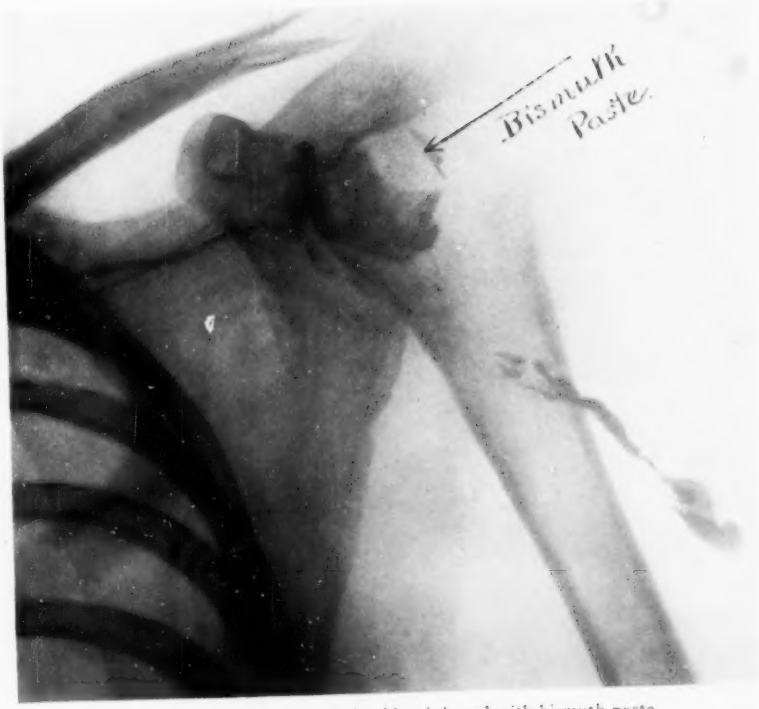

FIG. 12.—Tuberculosis of shoulder, injected with bismuth paste.

FIG. 13.—Extra-articular infection.

Tuberculosis of scapula, including glenoid cavity. Miss S. G., aged eighteen, developed tuberculosis of spine at the age of three; wore a corset for two years and a spontaneous cure followed. Ten years later she developed a swelling in the middle of her upper right arm on the left side. The condition was diagnosed as a dislocation of the shoulder, and under anæsthetic the physician tried to reduce it. Later it was found to be an abscess, which was incised and drained. Condition then was supposed to be an osteomyelitis of the humerus. The discharge of pus persisted until March, 1917 (three years), when I first saw her and injected the sinus with bismuth paste and found the following (Fig. 12):

The sinus leads into the glenoid cavity, the head of the humerus is eburnated, the glenoid cavity devoid of cartilage and the external border of the scapula shows the healed out tuberculosis.

The injection of the paste had the effect of promptly closing the sinus within two weeks. Same has not reopened, and motion of the shoulder has become almost perfect.

Extra-articular abscess following injury, mistaken for tuberculous knee. J. V., a boy eight years of age, received a slight injury to his knee by falling, in January, 1909. This was followed by lameness. The condition, however, did not become much aggravated until April, when a swelling and pain of the knee developed. The physicians in California diagnosed the condition as tuberculosis of the knee and advised resection. His home being in Chicago, he returned and again consulted surgeons, who also diagnosed the condition as tuberculosis of the knee with the same advice, " resection."

In this condition the patient entered the hospital in August, 1909. With the aid of a set of stereoröntgenograms of the knee, the diagnosis of tuberculosis became doubtful, only an extra-articular abscess without bone lesion was suspected.

Through a small incision I evacuated about two ounces of pus (staphylococcus). Injection of this abscess (Fig. 13) shows the extent and ramifications of the undermined extra-articular pus pockets. A stereoscopic picture proves beyond a doubt that no pus or paste entered the joint itself and the further progress of the case proved the correctness of our diagnosis. Within three days the sinus closed and within one week the boy had perfect motion and normal shape of his knee. A radiogram taken six weeks later shows the perfect joint, without the slightest destruction of any bony tissue.

Even with the correct application of the bismuth paste there will remain a certain number of cases uncured because of the inaccessibility of the injection to all diseased parts or of the retention of a foreign body. For such cases a most radical procedure is necessary, which I shall here describe.

Skin Sliding Operation for Osteomyelitis.—The principle employed is practically the same as that in the lung abscess cases.

The diseased area, being located by means of radiograms, is freely exposed by cutting away all the unhealthy skin and scar tissue. The diseased bone is then thoroughly curetted or chiselled away until one is certain that

there is not a vestige left. Should this produce a deep groove, the same must be converted into a very shallow one or even into a flat surface by cutting away a sufficient quantity of healthy bone on either side.

This being done, a skin-flap is cut from one or each side, sufficiently large to nearly cover the denuded bone surface, care being taken, however, that no subcutaneous fat is carried with it. The flaps are then shifted into the depth of the cavity and retained there by packing gauze against them. It is not absolutely necessary that every part of the bone cavity be covered. The skin will grow from the edges of the flaps until every portion of the raw bone surface is covered with true skin. To prevent retraction or slipping of the skin-flaps, I have frequently used a carpet tack to temporarily fasten the tip of the skin-flap to the bone until adhesion has taken place. The areas of muscle and subcutaneous tissue which have been exposed by sliding the skin are left denuded. No attempt should be made to bring their edges together by suture or otherwise. In only very rare instance has it been necessary to use any suture material whatever, except, of course, the ligation of bleeders.

When the wound is not too deep, the skin-flap may be omitted. It is simply left widely gaping and packed with gauze and allowed to granulate from the bottom. Later on adhesive plaster is put on the edges of the wound. This procedure has thus far been carried out in 34 cases; a variety of diseases including osteomyelitis and tuberculosis of joints, among which are two cases of spondylitis. There was no mortality. All cases have closed except those which have been operated upon too recently. These are progressing satisfactorily.

A detailed report of these cases will be given in a future publication.

SUMMARY

1. The methods of primary sterilization by means of flushings with hypertonic solutions should be thoroughly tested, to determine their effectiveness without the additional use of pastes.

2. The radical excision of infected tissues, as now practised in the war hospitals, should be adhered to, as a means of preventing chronic suppuration.

3. In those cases in which early sterilization was not obtainable and the wounds persist in suppurating, the bismuth paste injection or similar formulæ should be employed, before another radical operation is resorted to.

4. Correct technic in applying bismuth paste is essential if satisfactory results are to be obtained.

5. Bismuth paste and similar formulæ are applicable in chronic suppurations resulting from war wounds, as well as in those due to chronic infectious diseases.

6. In the residue of cases in which the bismuth paste treatment is not effective, the sutureless skin sliding operation[9] should be employed, since with this method we are able to clear up nearly all of these apparently hopeless cases.

[9] E. G. Beck: Surgery, Gynecology and Obstetrics, March, 1918.

INJURIES TO THE MALAR BONE AND ZYGOMA

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In current descriptions of injuries to the face it is noticeable that attention is directed largely to fractures of the nasal bridge and mandible. In view of the very obvious disabilities produced by blows upon these regions this is not surprising, but there are other bone injuries generally dismissed after the briefest notice either because of their comparative rarity or from the fact that they do not force themselves upon the attention of the clinician by any serious consequences. As an example of the former group, fracture of the maxilla in industrial accidents may be cited. The object of this paper, however, is to call attention to effects of blows upon the cheek, blows which may produce quite extensive damage yet, owing to the defensive mechanism of the face, easily pass unrecognized.

Damage to the cheek results in local extravasation and in swelling, features which obscure the actual condition of the bones. Some temporary disability in the action of the masticatory muscles may result, but there is often no concussion as from a knock-out blow, and since actual permanent interference with normal functions is rare, there is as yet no adequate description of the lesions so far as I have been able to discover. The construction of this part of the face, which, because of its exposed position, is so liable to injury, lends itself to the absorption of shocks and the irradiation of blows, and from this point of view is most instructive. The effect of a blow upon the zygoma or outer border of the orbit is localized by the fragility of the bones and is not transmitted to regions further afield as in the case of the mandible: hence the relative immunity from concussion. In consequence of the facial architecture no permanent sequelæ are likely to develop, save a localized deformity of varying extent. Permanent interference with the mechanism of the temporomandibular joint, the action of the masticatory muscles or the suspension of the eyeball is rare.

In a survey of the literature it is apparent that estimates of lesion to the malar and its processes are computed by the only cases which come under clinical observation. These include widespread fractures in which the lesion to the malar is merely an incident and occasional cases in which damage to the malar or zygoma alone has resulted in marked disability. They do not include those extensive injuries which result in speedy death or the majority of cases of more local damage.

Murphy [1] and Rawling [2] refer to instances of very severe injury only. Speed [3] notes that only seventeen cases presented themselves at Cook County Hospital, Chicago, in eight years. Authors in general agree in stating that fractures localized to the malar bone and its immediate neighborhood are rare. Roberts and Kelly [4] hold that fracture of the malar body is more

common than fracture of the processes and that true suture dislocation seldom occurs. Stimson[5] observes that single fractures of the malar are rarer than multiple ones, and that the rarest form is simple separation at the sutures with some splintering; but he indicates the inadequacy of clinical statistics by his statement that only in one recorded case has displacement interfered seriously for any length of time with movement of the jaws, and even this case recovered without treatment.

It is with the view of correcting the impression gained from clinical observation alone that the present investigation is recorded. I shall not refer in the following description to those instances which from the severity of the injury terminate speedily in death, but shall include only the cases which are of clinical importance and those which, since they are not followed by sequelæ forcing themselves upon the attention of the patient, do not come under clinical observation.

In examining the cheek bones of a collection of skulls for lesions, many of which are not very obvious at first sight, there are two pitfalls which must be avoided. The first of these is variation in the shape of the zygomatic arch itself. In the great majority of European and negro skulls the zygomata are curved in symmetrical fashion to form arches convex laterally. Occasionally a skull is found in which the zygomata are not arched but form uncurved bridges across the temporal fossæ. A few skulls show asymmetrical zygomatic arches. In these variations from the usual architecture there is nothing to indicate violence: they are therefore eliminated from the present discussion. A condition not very infrequently found, resulting apparently from slight disharmony in growth, is a pseudoluxation of the suture between the orbital process of the malar and the great wing of the sphenoid. This is the second type of anomaly to which reference must at once be made. In such cases there appears an angular union of the bones at this suture or, more rarely, an overlapping of the sutural edges. When one thinks of all the correlation which is involved in orderly growth of the face it seems remarkable that this type of disharmony is relatively rare and little marked.

Setting aside the foregoing peculiarities it is now possible to proceed directly to the consideration of pathological results of blows upon the cheek.

In the museum of this laboratory are thirty-eight skulls showing definite lesions of the type under discussion. All are the skulls of Europeans or of American negroes. Any considerable collection naturally represents individuals of varied social grade. To gain a fair idea of the percentage of this injury it is essential to define the social scale of the population examined. In our collection the European and negro skulls are those of individuals of the lowest grade of social life in America, human derelicts such as ultimately find their way into the dissecting room. On the other hand, the skulls belonging to individuals of other races, so far as our collection goes, represent the population at large without discrimination. Since lesions of the character under discussion may be expected to occur much more com-

monly in the lowest social grade, it would only vitiate our statistics and give a false impression of the frequency of the injury were we to include in the survey the skulls of individuals other than European or negro.

Confining our attention to the European and American negro collection,* there have been examined 373 of the former and 94 of the latter. Among the 373 Europeans, 31 †, or 8.3 per cent., showed lesions of the cheek bones, and among the 94 colored there were 7, a percentage of 7.4. No doubt the difference in percentage is negligible and results from the much smaller proportion of colored skulls at hand. In the combined total of 467 individuals 38, or 8.1 per cent., had suffered pathological deformation resulting from blows upon the cheek.

FIG. 1.—Base view of skull (465) of white male aged fifty, illustrating a very frequent type of damage to the zygoma producing no appreciable ill effects.

No particular light is thrown by this examination upon the age at which the injury occurred. All are old healed lesions.

Regarding sex it is worth noting that only two skulls are those of females (both European). From the nature of the injury it is plain that it will be rarely found in female skulls.

DESCRIPTION OF CASES.—*Zygomatic Series.*—Injury restricted to the zygomatic arch. Of this type there are two degrees, depression and fracture-dislocation.

Depression alone of the zygoma, usually most pronounced at the temporomalar suture (Fig. 1), occurs sixteen times, the injury being on the left side in ten cases and on the right in six. The two females (skulls 355 and 411) exhibiting injury both fall into this series.

The more severe form (Fig. 2) in which fracture of the arch or dislocation at the temporomalar suture occurs is found fourteen times, twelve

* The following skulls have been examined: White, Nos. 0.1–0.130, 15–518. Colored, Nos. 0.47–0.131, 25–528.

† Skull 295 exhibits a lesion on both sides.

times on the left side and only twice on the right. The injury may or may not be accompanied by depression of the arch. Fracture may occur in the temporal part of the arch or in the malar part or in both, but the temporo-mandibular joint is never involved. When depression occurs it is less marked as a rule than in the foregoing type.

FIG. 2.—Skull (97) of colored male aged fifty, showing more severe injury to zygoma. Fracture of the arch has occurred in three places but is now healed with very little callus formation.

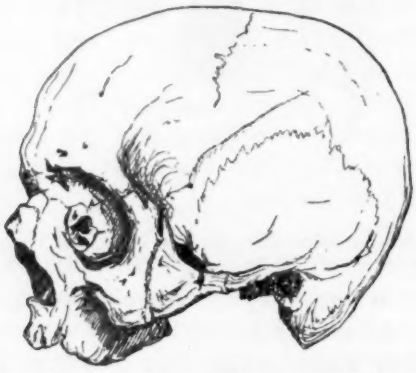

FIG. 3.—Skull (0.35) of senile white male, presenting an unusual type of injury to the zygoma. A rare congenital anomalous vertical separation of the malar into two has permitted bending at the anomalous suture in addition to the more typical fracture-dislocation of the zygoma proper.

An unusual example of the second class is illustrated by Fig. 3, in which a rare and anomalous vertical subdivision of the malar is present. Separation of the two portions of the bone has resulted from the force of the blow.‡

‡ Doctor Hrdlička has reported a case similar to this with some uncertainty as to whether it is a mere fracture or a genuine malar subdivision complicated by fracture. It is therefore important to note that there is a vertical suture on the mesial aspect of this malar bone almost coinciding with the line of fracture. The suture is not visible on the lateral aspect and it is unfortunately unilateral. Since this article was written another skull (No. 534, male, white, aged sixty-eight) has been added, which presents a similar lesion on the right side, but in this case there is no vertical suture to be seen. It is therefore probable that Dr. Hrdlička's interpretation that a line of fracture can occur here is correct and that the vertical suture seen in skull 0.35 bears no direct relation to the site of fracture. (See Hrdlička, *A. Am. Nat.*, 1902, vol. xxxvi, p. 292.)

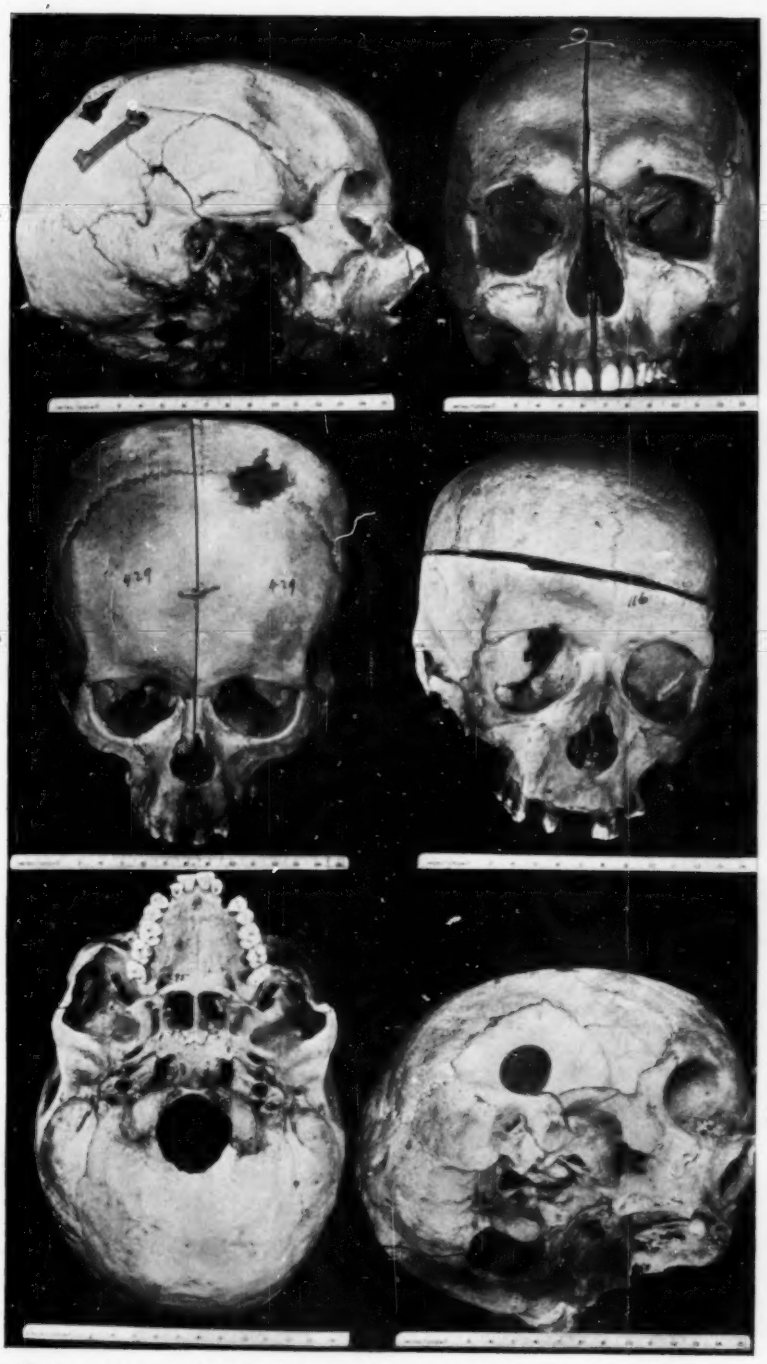

FIG. 4

FIG. 5

FIG. 6

FIG. 7

FIG. 8

FIG. 9

FIG. 4.—Skull of white male, showing rotation and depression of the malar complicating a sword wound of the vault. The braced fracture and the loss of bone in the parietal region occurred after death.

FIG. 5.—Skull of white male aged fifty, showing lowering of the orbital margin and buckling of the maxilla resulting from a blow directed upon the lower margin of the right orbit.

FIG. 6.—Skull of white male aged forty, showing destruction of the entire floor of the right orbit consequent upon a blow on the malar.

FIG. 7.—Skull of white male aged fifty, to show fracture of the right malar body clear into the sphenomaxillary fissure.

FIG. 8.—Skull of white male aged forty-one, showing the displacement backwards of the outer orbital margin resulting from a blow which has buckled the left maxilla.

FIG. 9.—Skull of white male aged forty-five, to show dislocation of the temporomalar suture and buckling of the maxilla following a blow on the malar.

FIG. 10.—Skull of senile colored male, showing the forcing apart of the two portions of a bipartite malar bone in addition to fracture-displacement of the zygomatic arch. Note the osteophytes on the zygoma and on the attachment of the temporal muscle immediately adjacent to the anterior root of the zygoma.

Malar Series.—Injury centring on the malar bone. Examples illustrating this type may well receive a closer individual scrutiny because of the varied effects resulting therefrom. The blow results in crushing back of the malar, deformation of the orbit and buckling with fracture of the maxilla. Five times the lesion occurs on the right side, four times on the left.

As a first example of this series skull 0.117 (Fig. 4) is presented. It is that of a white male well beyond middle life and displaying a rather feminine cast of features, who has been struck by an edged instrument (probably a sword) upon the side of the head. There is a linear fracture, long healed, extending through the right parietal, the squamous temporal and great wing of the sphenoid. The right malar has been displaced and there is depression of the bone near the temporomalar suture. The frontomalar, malar-sphenoid, and malar-maxillary sutures are dislocated and the malar rotated about a vertical axis, the maxillary process being thus drawn away from the maxilla itself.

Skull 189 is that of a white male aged forty-three, and illustrates upon the left side a condition similar to that in the foregoing instance, except that the injury has been produced not by a sharp instrument but by a blow of the fist. There is the same depression and vertical rotation of the malar and dislocation at the same joints. But in this case the maxillary process of the malar, being very fragile, has been broken across instead of being wrenched off from the maxilla.

In skull 492 (Fig. 5), that of a white male aged about fifty, the blow has fallen directly upon the lower margin of the right orbit. The maxillary process of the malar is broken and depressed, causing lowering of the orbital margin. The facial aspect of the maxilla is buckled.

In the ensuing six skulls the blow has been delivered more directly upon the body of the malar.

Skull 429 (Fig. 6), belonging to a white male, aged forty, shows that considerable damage may occur with but slight facial evidence. A first glance indicates merely that upon the right side the frontomalar suture has been dislocated, the bones being pried apart quite considerably, and that there is some buckling of the facial aspect of the maxilla with depression of the inferior orbital margin. Further inspection reveals destruction of the entire orbital floor. The zygomatic process of the maxilla bearing the malar has been wrenched away from the rest of the bone, the facial and infratemporal surfaces being split and continuity maintained only below. There is but slight depression of the zygomatic process of the malar and rotation of the bone around its vertical axis.

In skull 116 (Fig. 7), that of a white male aged fifty, fractures occur in the zygomatic process of the squamous temporal and in the body and orbital process of the malar immediately above the zygomatic foramina. The latter fracture extends into the inferior orbital (sphenomaxillary fissure). In addition the frontomalar and malar-sphenoid sutures are dislocated. Around the root of the zygomatic process the facial and infratemporal surfaces of the maxilla are split and the base of the process driven into the maxillary antrum. No doubt the fractures of the bones prevented greater buckling such as is found in the next specimen.

Skull 295 (Fig. 8), belonging to a white male aged forty-one, has been included already in the zygomatic series since it displays upon the right side depression of the zygoma at the temporomalar suture, but must also be referred to in the malar series because it presents a marked deformity upon the left side. In this case a blow delivered directly upon the cheek has buckled in the temporal process of the malar as well as the zygomatic process of the maxilla, the latter damage being accompanied by some

destruction of the infratemporal and orbital surfaces of the upper jaw. In addition to these, there is fracture of the orbital process of the malar and dislocation of the frontomalar suture. The nasal bones also are fractured and displaced to the right, probably as a result of the same blow.

Skull 148 is that of a male white, aged fifty-five. Again the damage to the left cheek area is complicated by fracture of the nasal bridge with displacement to the right. There is dislocation at the temporomalar suture accompanied by some depression of the temporal process of the malar bone. The malar-sphenoid suture is dislocated. The entire maxilla has been comminuted, orbital, infratemporal and facial surfaces being involved, the last mentioned mesial to the infra-orbital foramen. The floor of the orbit is depressed.

Skull 419 (Fig. 9), from a white male aged forty-five, has suffered like but more extensive damage, although the dislocation at the temporomalar suture is not complicated by depression of the temporal process of the malar bone. The frontomalar suture has been loosened in this instance.

Skull 0.47 (Fig. 10), which also falls into this group, is at first sight difficult to interpret. It is that of a senile male American negro. Comparison of it with Fig. 11, which is an outlined sketch from skull 0.62 (colored, male, aged forty-five), gives the explanation. There has been upon the left side a bipartite malar bone the two portions of which have been separated by the blow. The forcing apart of these has been con-

FIG. 11.—Skull of colored male aged forty-five to show the bipartite malar bone. Compare this with Fig. 10.

tinued as a splitting of the maxilla. Other complications are also present. There is fracture of the greater wing of the sphenoid with dislocation of the malar-sphenoid suture and fracture of the zygomatic process of the temporal. Some local osteophytic growth occurs on the zygoma itself, on the anterior root of the zygomatic process of the temporal and on the coronoid process of the mandible. The upper fragment of the malar was wrenched by the blow almost entirely free from the rest of the facial skeleton, although later firm union occurred.

Interpretation of the Foregoing Observations.—Having stated the pathological results of blows upon the cheek as exemplified in the present study we may consider briefly certain general aspects of the injury. As already stated, lesions of this nature occur with greatest frequency in the lowest grade of society. There is a sharp distinction between the less extensive type of injury, that confined to the zygomatic arch alone, and the features resulting from a blow upon the body of the malar. Whereas among the former graded injuries occur, the latter are invariably severe. Nowhere in our museum are there to be found specimens showing only slight damage of

the malar series type. Apparently, therefore, the force of less heavy blows is effectively absorbed by the resilience of the facial skeleton and dispersion over the several buttresses converging upon the malar bone. It is obvious, however, that beyond a certain limit the buttresses give way or the maxillary base of the malar buckles. Thus the force of the blow is absorbed and further ill-effects minimized. "Spent" blows are not represented in the malar series.

From the damage described certain deductions can be drawn regarding the character of the blow. In the zygomatic series in general lesions occur most frequently upon the left side. In the less severe grade, where there is merely depression, we find ten instances of left-sided and six of right-sided injury. There is here a much higher percentage of injuries of the right face than in the other classes discussed below. Allowing for the non-scientific character of the fighting it would appear that these lesions are produced either in parry or in counter-blow, the face being turned to the side. The parry by the guard arm would greatly diminish the force of a direct blow and the counter-blow would rarely have the strength of a direct thrust. In both cases the recipient's side face is exposed. In the more severe grade of the zygomatic series, that in which the arch is fractured, the lesion is found much more frequently upon the left side (twelve times left, twice on right). This may reasonably be interpreted as the counter-blow of a stronger opponent delivered while his antagonist is at the stage of recover, although some of the injuries are probably from direct thrusts. In the malar series damage occurs with equal frequency on both sides (left four, right five) and since less forceful blows are not illustrated there are fewer instances than in the zygomatic series. Parried blows and counter-thrusts are not represented. In every case there has been a direct blow which the opponent has had no opportunity of resisting effectively: He has not even turned his face to receive the blow upon his zygoma.

We must now consider the effects of the damage details of which are at first obscured by swelling. Crushing in of the zygoma in either zygomatic or malar type may affect the movements of the temporal muscle. That such a result does follow is indicated by skull 0.47 (Fig. 10), in which osteophytic growths in the attachments of the temporal muscle and fascia are seen. There is no doubt that this sequela does not always occur. Dr. J. J. Thomas tells me that he has observed such depressions without any resulting interference in muscular movements. Dr. C. A. Hamann informs me that he has noted pain and difficulty in moving the muscle shortly after the injury, but since these cases do not continue to present themselves for treatment and, again, since of all our series 0.47 alone exhibits any osteophytic outgrowth either on skull or mandible, it may be presumed that these symptoms shortly subside. Only in one case (skull 358) did I find any arthritis of the temporomandibular joint. As arthritis of this joint is not very infrequent in our collection and skull 358 exhibits merely slight depression of the zygomatic arch, I am disinclined to consider it consequent upon the

damage to the facial skeleton. In no instance is there evidence of prolonged suppuration in the maxillary sinus. Regarding the infra-orbital nerve there is no evidence to point to injury. In every case in which the floor of the orbit is damaged (skulls 148, 295, 419, 429) at all extensively the injury passes either mesial to or through the infra-orbital groove and canal but without resulting constriction or wide separation of bone fragments.

Passing to the effect upon the orbit we note that this may be quite marked, yet whether this has influence upon the slinging of the eyeball between the attachments of the tarsal ligaments is another matter. Distortion of the orbit is necessarily a result of direct blows delivered with some violence upon the malar; it does not result from blows upon the zygoma. The lateral wall is frequently set back especially below and the lower margin is depressed. The latter deformity increases the vertical orbital height, but since this varies so greatly with the individual, with sex and with age, it is not conceivable that it can have any functional significance. Alterations in the transverse breadth of the orbit may be more important as such a deformity may affect the position and tension of the suspensory ligament which is attached to the lachrymal and malar bones.

Customary anthropological measurements of orbital breadth are made without reference to the suspension of the eyeball and are therefore useless in the present connection. In order to have a standard I took fifty European skulls (281–356) and measured with sliding calipers the distance between the dacryon and the malar tarsal tubercle.[6] The former point (junction of sutures between frontal, nasal process of maxilla, and lachrymal) afforded a fixed point close to the inner attachment of the suspensory ligament which itself is often difficult to identify on macerated skulls. The latter point was adopted because it indicates precisely the lateral attachment of the ligament. Of these fifty skulls the orbital breadth was the same on both sides in twenty-two; the right orbital breadth was the greater in fifteen; the left greater in thirteen. In only one case (skull 336) was the difference between the orbital breadths of the same skull more than one millimetre. In this skull there is general asymmetry.

Referring to the lesions noted in the present survey it is plain that only in the malar series may we expect to find any possible effect upon the position of the eyeball, and even here, as indicated by Murphy's case, the excursions of the eyeball are not likely to be altered in extent. The only effect short of blindness from a lesion of the optic nerve or macula or of bursting of the eyeball will be loss of stereoscopic vision. This is brought about by displacement of the axis of the eyeball in consequence of change in relative position of the malar tarsal tubercle. Of the nine cases in this series displacement of the tubercle in the three dimensions of space can be tabulated in the following manner:

Displacement in the transverse horizontal axis is suggested in four. For the sake of simplicity the orbital breadth on the sound side may be taken as the normal for each skull.

Skull No.	Displacement of malar tubercle
0.117	4.0 mm. laterally.
189	1.5 mm. medially.
295	1.5 mm. laterally.
419	1.0 mm. laterally.

In the first of the foregoing instances there is no doubt that displacement occurs: in the others displacement may be doubted in view of the normal variation in orbital breadth on the two sides, a variation which does not exceed 1 mm. The suggested displacement is, however, important in association with the figures in the following lists:

Displacement in the vertical direction can be gauged by separation of the fragments in fracture-dislocation of the frontomalar suture, a lesion which in the present survey occurs much more frequently at the suture than in the bone adjacent. The extent of the gap indicates the displacement of the tubercle. It occurs in four skulls.

Skull No.	Vertical displacement of malar tubercle
0.117	1.5 mm. downward.
295	2.0 mm. downward.
419	1.5 mm. downward.
429	2.0 mm. downward.

Displacement of the tubercle backwards will obviously be the most extensive and accompanies the crushing back of the malar. It is suggested in seven of the skulls. This measurement was taken by placing one limb of the sliding calipers in the external auditory meatus so that it rested upon the anterior margin at the junction of tympanic and squamous temporal portions; the other limb was then adjusted to the orbital margin at its nearest point to the meatus. The difference between the readings on the two sides gives approximately the displacement of the malar tubercle. In order to check off this against the normal fifty European skulls (281–360) were measured in the same manner. In normal skulls the measurement was either the same on both sides or varied not more than 0.5 mm. to the right or left unless general asymmetry occurred in face or entire skull on the one hand or marked loss of teeth on the other. The point upon the orbital margin nearest to the external auditory meatus is so close to the malar tubercle that this convenient measurement was substituted for the more difficult direct estimate. The figures given by the normal skulls indicate that we may ignore the displacement in skull number 189 only, though even then the difference in this measurement is probably to be associated with the difference noted in the first list.

Skull No.	Displacement of malar tubercle backward
0.47	2.0 millimetres.
0.117	1.0 millimetre.
148	5.0 millimetres.
189	0.5 millimetre.
295	2.0 millimetres.
419	1.0 millimetre.
429	3.0 millimetres.

It will be noted from the foregoing statistics that the most constant permanent result of damage to the malar bone is alteration of the axis of the eyeball. Whether this is followed by interference with stereoscopic vision, at any rate in the cases of less pronounced axial alteration, would be a matter for clinical observation. In examining normal cases I find that there is a distinct difference between the distance of the orbital border from the external auditory meatus in those individuals who have lost a considerable number of teeth on one or both sides, whereas this does not obtain in skulls still retaining a practically full dentition. So far as I am aware, no observations have been made upon the relation of vision to this change in facial form. Even if interference with stereoscopic vision does occur with moderate injury to the malar bone it is not a result which will readily cause the patient to seek treatment. In any case there is no limitation of the excursions of the eyeball.

Defects of vision, whether purely temporary as met with in such cases at the present time in France and as recorded in McCurdy's case,[7] or permanent from lesion of the optic nerve, hemorrhage into the macula, and sluggish pupillary reaction,[8] like formication or anæsthesia in the area supplied by the infra-orbital nerve, and hemorrhage or inflammation in the maxillary sinus, the present material does not permit us to discuss.

Lastly, more or less temporary interference with the action of the masseter is not confined to the malar series, but is even more characteristic of the zygomatic group. No permanent disability is likely to result, and in none of my cases are there osteophytic deposits in the masseteric attachments.

SUMMARY

In summing up the foregoing observations one may state that contrary to the usual impression fracture or fracture-dislocation of the malar bone occurs alone or with extension only to the maxilla more frequently than as part of a widespread lesion; and that damage to the zygomatic arch is much more common than injury to the malar itself. The failure so far to appreciate these facts is quite natural, for the great majority of cases never come under clinical observation since they are accompanied by no permanent disability causing the patient marked inconvenience. The most frequent permanent derangement appears to be deviation of the axis of the corresponding eyeball. Interference with the action of masticatory muscles is usually temporary and affection of the infra-orbital nerve results in no pronounced symptoms.

Involvement of the temporomandibular joint, permanent blindness and other grave complications result from a much more severe injury. Cases exhibiting such serious disabilities form by far the greater number of those presenting themselves for treatment. Instances of less severe damage do not usually appear upon clinical records.

Finally, we note that the very fragility of the facial skeleton in this region and its normal resilience form a natural protection against marked untoward effects.

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One of the most fully reported cases in the recent literature is the following:

Okinczyc, J., et Küss, G.: Les luxations de l'os malaire. Rev. de Chir., 1907, T. 35, pp. 100–111.

KINEPLASTIC AMPUTATIONS

By Vincent Gaudiani, M.D.
of New York

The utilization of mutilated members is not merely a surgery of sentiment but of high social duty. When a proper mechanism can partially replace the function of the lost member, the community will not completely lose the efficiency of the individual.

In the technic of amputations there has been in the last few years no other progress than that directed to the securing of a good weight-bearing power of the stump. The large number of amputations during the present war has attracted the attention of the surgeons to those methods which can be better adopted for the future application of a useful prothesis capable of relieving a crippled condition. It has been for this reason that the *kineplastic amputation,* originated by Vanghetti, has been newly brought into light by the work of some Italian and German surgeons. It is not my intention to discuss the reasons why a method of such social value has been so little appreciated and applied. Very probably the conservative tendency of modern surgery and the great limitation of the amputations prevented a wide practical test of the Vanghetti experimentations. Besides, the necessity of having the coöperation of a mechanician to construct and fit a rather expensive apparatus, and the importance of a long and proper training of the patient, did not favor in peace times the spreading of a surgical method for which special institutions would have to be created.

In performing an amputation, the surgeon takes advantage of the soft tissues to cover and protect the bones. The muscles which have been cut through, being deprived of their distal insertions and having lost their functions, subsequently undergo a more or less extensive atrophy. In 1896 Vanghetti, by ingenious experiments on animals, tried to demonstrate that if the muscles of an amputated member are properly covered with skin and protected from retraction they can preserve their function of voluntary contraction and may be used to transmit motions to some mechanical apparatus. The muscles or tendons which, properly prepared by a surgical operation, become apt to animate a prothesis, are called by him *plastic motors.*

The varieties and types of motors that can be obtained in an amputation stump depend on the place where the amputation takes place and on the special condition of the diseased part. Vanghetti, in a series of papers, has widely developed the theories of the motors and has described a great number

of them. For practical purposes they can be classified into two fundamental types, so far as their form is concerned: the *loop* and the *knob*.

The *loop* is made by the natural or artificial union of muscles and tendons, forming a space through which a ring can be adapted to transmit contraction outside.

The *knob* is an enlargement of the tendons or muscle-endings formed by the surgeon, either by twisting and suturing together a number of tendons, or by using a bone eminence where the tendon is attached.

Both loop and knob should be completely covered with skin. The knob will result in an enlarged part, the *head*, and a thin part, the *neck*, to be used to transmit the movements by applying a belt.

In regard to the way in which the function is performed, they have been classified as:

1. Motors that can execute movements only in one direction (simple motors or unimotors). A various number may be formed on the same stump so as to give different movements to the artificial limb.

2. Alternating motors or bimotors. These are capable of movements in two opposite directions. They are formed by suturing the antagonistic muscles on the section of the bone or on the articular surface (Fig. 10).

The kineplastic method can be adopted in every case of amputation, especially in those of the upper limbs (primary kineplastic amputation), by forming loops or knobs at the end of the stump. In other cases, by the careful suturing of the muscles over the section of the bones, the stump can be so prepared that the function of the muscles is preserved for a long time and a secondary kineplastic may be performed with a rather easy operation. This process has been called by Vanghetti *transitory kineplastic amputation*. Nearly ten years ago, almost at the same time, the Russian surgeon, Von Wreden, and the Italian De Francesco succeeded in forming plastic motors on old stumps which were the result of operations performed according to the old methods. As it would be rather difficult to formulate theoretical rules for kineplastic amputations, I will rapidly review the literature, and give an outlook on the technic followed by the surgeons who have practically applied the method.

CASES OF PRIMARY KINEPLASTIC

Ceci (Pisa): It was Prof. Ceci of Pisa who first practically applied the theoretical and experimental work of Vanghetti. In the Surgical Clinic of the Royal University of Pisa, the first kineplastic operation was performed in 1900 and the case reported at the Italian Congress of Surgery (1905).

Case I.—This case was a myxosarcoma of the radius with metastasis. The ampu-

tation was performed at the lower third of the arm with a loop between the biceps and triceps. Ceci made a circular flap of skin and subcutaneous tissue, one inch below the elbow-joint, which was dissected and turned up on the lower third of the arm. The bone was sawed, after carefully detaching the tendon of the biceps, whose ending was sutured to the triceps tendon forming a loop. Three centimetres above the margin of the skin flap, two lateral incisions of nearly five centimetres in the axial direction were made, so as to correspond to the middle of the tendinous loop. By suturing the edges of one incision to the corresponding edge of the other, a button-hole in the centre of the loop was the result (Fig. 1). The circular flap was sutured in an anteroposterior direction. As soon as the scar was solid enough, traction exercises were started through the ring, formed by the skin and underlying tendons, and in a short time the patient could easily raise four pounds. The loop was afterward provided with a ring and the contractions were transmitted to an artificial hand made by Redini of Pisa (Fig. 3).

Case II.—Recurrent tuberculosis of metacarpophalangeal joints (1912). Amputation at the inferior third of the forearm. Tendinous loop between the extensor and flexor tendons. He dissected upward two rectangular musculocutaneous flaps, with superior basis. The endings of the tendons were sutured together as a stirrup. The skin of each flap was sutured so as to cover the loop. This case was a failure on account of necrosis of the skin.

Case III.—Amputation of the inferior third of the forearm, for recurrent tubercular condition of the wrist-joint. In this case he attempted to form two independent motors. One was formed with the group of flexor muscles and the other with the group of extensors. The motor formed by the flexor tendons was used to give to the artificial hand the palmar flexion, while the extensor tendons were used to abduct the thumb. It is interesting to note the technic used in this case to cover the tendinous loop with the skin. On each cutaneous flap he made two longitudinal incisions at different heights and at such a distance that by turning the flap on itself, with the subcutaneous tissue inside, the incisions would correspond with each other to form a button-hole in the centre of the tendinous loop (Fig. 2, schematic reproduction).

Alessandri (Rome): In 1906 Alessandri performed an amputation at the inferior third of the forearm with the plan to obtain two motors, one with flexors and one with the extensor tendons. He sutured together, at one end (dorsal), the extensor ulnaris with the radialis and a portion of the common extensor. On the other side (palmar) he stitched together the long supinator and internal palmar, with the flexor carpi ulnaris. Both loops were covered with the long quadrangular skin flaps which were sutured together all along the edges. A button-hole was cut in the middle of each loop, and sutures inserted along the margins. The operation was not successful on account of necrosis of the tendons and skin. The author warns against too complicated operations, and proposes performing the button-hole in a second stage when the vitality of the flap is insured.

Slawinski (Warsaw, 1912): Kineplastic amputation of the forearm in a case of recurrent tuberculosis of the carpal bones. Circular incision a little above the radiocarpal joint and two lateral incisions of nearly eight centimetres on each side of the forearm. The circular incision exposed the bones so that the saw could easily be

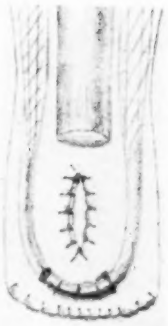

FIG. 1.—Schematic reproduction of Ceci's first operation.

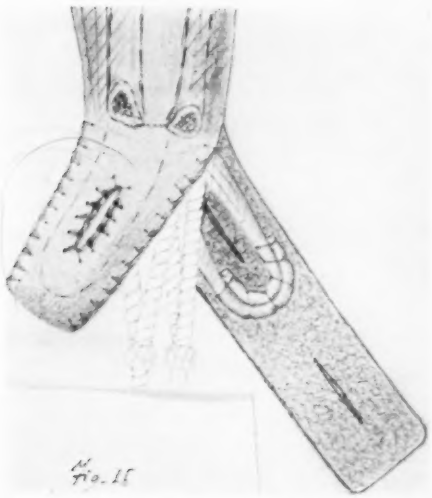

FIG. 2.—Schematic reproduction of Ceci's third operation: Anterior loop covered with skin; posteriorly shows tendon loop not yet covered with skin flap; tension strings applied. Same plan followed by Alessandri.

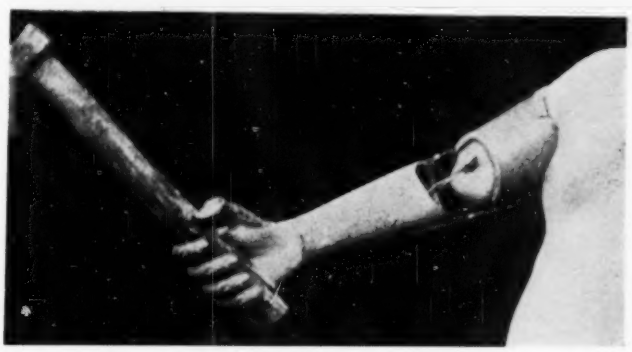

FIG. 3.—Ceci's first case with artificial hand. Note string through the loop (formed according to scheme in FIG. 1) animating fingers.

FIG. 4.—De Francesco's first case. Artificial hand voluntarily moved by a padded ring passed around the "neck of the knob." No other attachment.

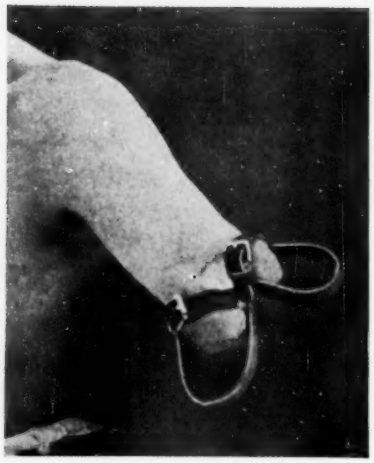

FIG. 5.—Putti's second case—double knob (flexor, extensor). Belt to move pulley of the prosthesis.

FIG. 6.—Codivilla's kineplastic exarticulation of the foot. Posterior knob formed with the calcaneus, anterior with the extensor tendons.

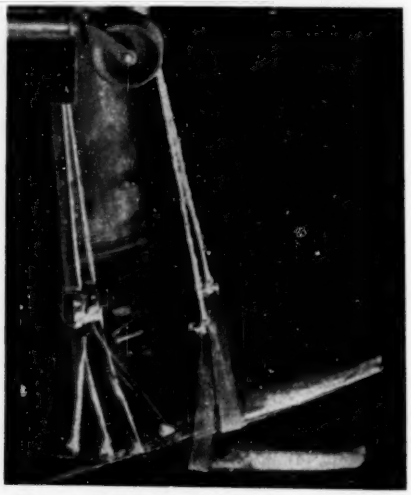

FIG. 7.—Shows movement of the prosthesis attached to an ergograph.

FIG. 8.—A double motor—one at extensor, one at flexor side (Sauerbruch).

FIG. 9.—Single motor on the flexor side—tube passed inside, with strings for exercises (traction) (Sauerbruch).

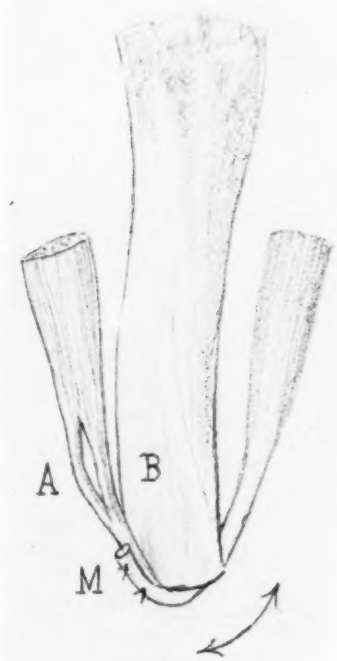

FIG. 10.—Reproduction of a bimotor (alternating motor). Schematic, from Pellegrini. *B*, bone; *M*, motor: *A*, attachment.

FIG. 11.—Suggestion of Pellegrini. A mobilized piece of bone used as an attachment of muscular loop in forming a bimotor.

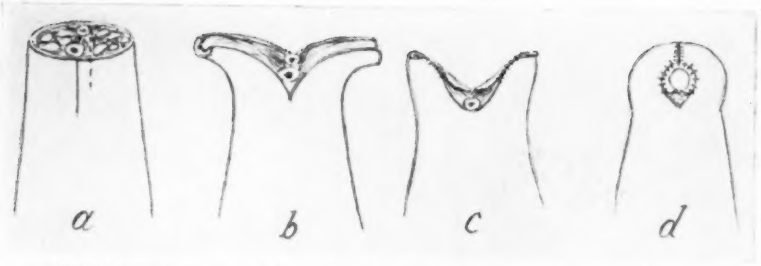

FIG. 12.—Pieri's suggestion for a primary kineplastic amputation. *a*, surgical preparation so as to have a Celsus stump—two-side incision; *b*, two flaps formed—bones sawed; *c*, sutures of flap to form two knobs; *d*, a motor loop is formed.

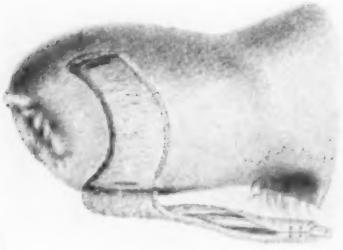

FIG. 13.—Muscular loop. Shows how to form a tube of skin for the exterior attachment (Sauerbruch).

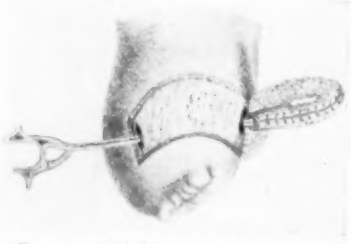

FIG. 14.—Cutaneous tube passed in a tunnel made in the motor (Sauerbruch).

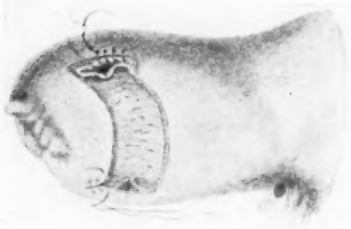

FIG. 15.—Further step in forming the exterior attachment (Sauerbruch).

FIG. 16.—Repair of the skin. Rubber tube passed in the tunnel (Sauerbruch).

applied after retraction of the flaps. Of the two lateral incisions, the superior half was carried to the bones and nearly three centimetres resected. Muscle-tissue was interposed at the site of the resection. The stump resulted, divided by the resected bones, in two unequal portions. The small distal portion (knob), which was left attached to the muscles, could execute movements of flexion and extension on the central bones.

A. Zoppi (Venice, 1915): Amputation at the lower third of the arm leaving a piece of olecranon attached to the tendon of the triceps to form a knob. An anterior loop was formed by the tendon of the biceps. Good function resulted.

Pieri (1917): His operations, recently published, are important for the fact that they were performed in a field hospital, soon after the injury. In three cases a shell had almost destroyed the hand up to the wrist. The section of the bones was completed a little above the radiocarpal joint. In the first of the series, a loop between the extensor and flexors was obtained and, by taking advantage of three cutaneous flaps, which were the result of the removal of the contused tissue, he succeeded in covering the loop. Although a necrosis of the skin and tendons destroyed partially the loop, he successfully utilized the stump for transmitting movements. This has been the simplest and most successful operation performed by Pieri. In the other two cases in which he applied a more complicated plan, trying to obtain three motors, the result was unsatisfactory as a primary result.

SECONDARY KINEPLASTIC OPERATION

The first operation to utilize old stumps, in which the muscles were capable of some contraction, was performed by Von Wreden, of Petrograd, in 1907. Man, of twenty-two years, who had already been amputated at the wrist. "The tendons of the forearm were strongly adherent to the terminal scar. They were put under tension by voluntary contractions of the muscles." This condition indicated to the author the possibility of applying the Vanghetti idea. He decided to use only the superficial and deep flexor, and performed under cocaine the following operation: "A small incision of an inch and a quarter in the direction of the tendons was made on the anterior side of the wrist. The tendons of the flexors sublimis and profundus were freely exposed. The superficial flexors were cut through at the level of their adhesion to the scar. These tendons were turned upon themselves and sutured on those of the flexor profundus. A loop was so formed between the tendons of the two muscles and the wound was closed with a few stitches. The loop which was outside of the wound was covered with two pedunculated skin flaps taken from the vicinity. The pedicles were cut two weeks after and the scar around the tendinous loop was so solid that one could start to give movements to muscles. The exercises were performed with a string passed through the loop. Little by little the patient was able to raise twelve pounds. An artificial hand was constructed according to Dalisch. The movements were transmitted through a nickel hook which fitted in the tendinous loop.

De Francesco (Giussano): Almost at the same time, in January, 1907, De Francesco made a movable knob on a man whose forearm had been amputated five years before at the inferior third. Two longitudinal incisions were made on each side of the stump, a little above the terminal scar, exposing the radius and ulna. A piece of each bone was resected about one inch long, one inch above the lower end. Both lateral

incisions were sutured. A traction was applied around the distal part of the stump by means of a special apparatus. After the wound healed a rubber padded ring was applied at the place of the resected bone. From this ring, cords transmitted motion to the artificial hand. Voluntary flexion of the fingers was obtained by tractions on the cords, relaxation could loosen the finger grip. After a while De Francesco noticed that the tension of the muscles had the tendency to approximate the free bony fragments and thereby lessen the space for the traction ring. To prevent this inconvenience and the fusing together of the two sections of bones, he removed completely one of the distal bones and put the other in a transverse position. Even in such a position the muscular retraction was so powerful as to make the space left by the resected bones almost disappear. Nevertheless, the patient could, with exercises, obtain an elongation of the neck of the knob around which the padded rubber ring could fit and transmit motions. The artificial hand was made by Marelli, of Milan (Fig. 4).

Case II (1908).—Amputation of the middle of the forearm by the circular method. A year after De Francesco tried to form a knob by the same method described above. But in this case he resected an inch and a half of the terminal part of the bones and transversely implanted one of them in the terminal part of the wound, expecting that the neck of the knob could easier be fitted with a ring. A wire was passed through the central canal of the transversely transplanted bone, to make traction. The transplanted bone was extruded shortly after the operation and the author, taking advantage of the terminal soft tissues, which after the loss of the bone preserved good movements, perforated them. After the healing, he adapted in the holes special ivory buttons, through which traction cords were adapted. Patient could easily make movements and raise a weight of 2 kilogrammes.

Case III.—Woman whose arm had been almost severed by a machine. After the crushed limb was removed, the humerus was sawed a little above the condyle. The tendons of the biceps and triceps, which had previously been cut through at their insertion (a piece of the olecranon was left attached to the tendon), were sutured together and covered with skin. Although the final result was very satisfactory, the patient refused to use the artificial hand.

Putti (Bologna): Soldier amputated at the inferior third of the arm. Kineplastic on October 15, 1915. Lateral incisions on both sides of the stump going over its terminal side. The incision is carried out so as to penetrate between the muscles of the anterior and posterior layer. The distal part of the humerus was resected to the extent of one-half inch, but it was left attached to the insertions of the anterior muscles. This piece of bone was buried in the muscular substance and covered with skin by suturing the edges of the longitudinal incision forming the anterior flap. With the posterior flap a knob was obtained by simply suturing together the longitudinal incision. Excellent result. Putti started the traction by using strips of adhesive plaster (adhesol) which were connected to a traction apparatus (Fig. 5).

Sauerbruch: During the present war Sauerbruch, Professor of Surgery in Zürich, has given the most extensive and practical application of the Vanghetti method. Although he claims that he started this kind of work at the suggestion of a mechanical engineer, Prof. Stodola, without knowledge of the previous work of other surgeons, it is really the kineplastic method, as originated by Vanghetti twenty years before, that he applied. Nevertheless, the technic of Sauerbruch, as it has

been worked out in a great number of cases, has many original points that are worth remembering. In his first report of five cases, he described three types of operation. In the first type he forms, with the flexor and extensor muscles, two cutaneous muscular flaps. After a convenient shortening of the bone, by suturing each flap over itself so as to form two pads (Kraftwülste), they will appear as divided by a small and superficial gap covered by skin. By refreshing, in the second operation, the margins of the gap and by suturing the opposite surface, one obtains a cutaneous canal through which a stick can be passed to transmit motions. This method was used for the high amputation of the arm, the force of the muscles being capable of giving movement to the forearm and hand. In the second type, by adopting the same system, he took advantage, in the same way, either of the extensor or of the flexor muscles. In these two types it was necessary to remove the bone a little higher. In the third type to prevent such inconvenience, he covered the end of the stump with a flap of skin taken from the chest. Afterward the muscular flap was transformed into a muscular ring as in types 1 and 2. In forming a single motor, he always used the flexor muscles as being more capable of strength. In the great majority of cases he adopted only one motor. Only in very special cases did he use more than one.

KINEPLASTIC OPERATIONS ON THE INFERIOR LIMB

Although amputations on the inferior limb are to-day performed in a greater number than amputations of the arm, they have attracted less attention of the surgeons, so far as the kineplastic operation is concerned. In fact, the surgeons feel satisfied when they have given to the patient a good stump which can bear the weight of the body and allow the use of an artificial leg. In amputations of the leg, on account of the special disposition of the muscles, the making of kineplastic motors is easier, but more skill is required so as to not interfere with the weight-bearing power of the stump, which is the most essential thing for the patient. Very recently, another German surgeon, Blenke, without apparently any knowledge of the rather old literature, has warmly recommended the kineplastic method.

Codivilla (Bologna) was the first to apply, in 1910, the Vanghetti principles on a case of amputation of the foot for tuberculosis of the tarsus. The case seems to me of such importance that I wish to refer to it extensively. "The methods," he wrote, "that had been applied in the amputation of the arm were not available. The stump ought to be so fitted as to support the weight power and at the same time transmit movements to the artificial foot. The most essential thing was to have a considerable degree of plantar flexion in such a way that the motors could have a rather wide excursion. The operation was performed as follows: A wide flap (skin, fascia, and plantar muscles) was designed and dissected to cover the stump. The basis of it was at the inner side, because the skin on the outer side was not healthy. Then two other flaps were dissected, one anteriorly with its basis on the ankle-joint and reaching way down, as far as the condition of the

skin allowed, another posteriorly with superior basis, and with an outside direction. The foot was disarticulated at the ankle-joint, and a piece of the os calcis was left attached to the gastrocnemius tendon. Only the malleoli were removed to give a flat shape to the articular surface of the joint. The tendons of the anterior muscles were sutured together and included in the skin of the anterior flap to form a knob, while the posterior external flap was used to cover the gastrocnemius tendon and the attached bone. The internal inferior flap was used to protect the extremity of the bones. The tension of the anterior and posterior muscles was obtained by passing silk strings through the basis of the flaps. These tension threads were removed after eight days. The result was the formation of an anterior and posterior motor controlled by the will. By their contraction, even the terminal cuff could slide on the bones. An artificial foot was constructed which could execute movements on the transverse axis. A concave and well padded plate of celluloid supported the terminal part of the stump. A leather belt passed around the motors transmitted flexion and extension movements" (Figs. 6 and 7).

Galeazzi (Milan): Case referred at the Italian Congress of Orthopædics of 1911. In a case of disarticulation of the foot, he followed the same plan of Codivilla, but in his case, the excursion of the motors proved to be not wide enough to allow ample movements. The knobs did not acquire an independent power of mobility, and the anterior one did not result big enough to give a good hold to the pulleys.

Putti (Bologna) formed a kineplastic cuff, with the following procedure, in a case of amputation for sarcoma of the tibia. Anterior and posterior flap, as for a typical disarticulation of the knee-joint. With the anterior flap, beside skin, patella and patellar ligament, he dissected a great part of the articular capsule. With the posterior flap he dissected the flexor tendons and a great part of the posterior capsule. Posterior tendons and patella tendon were stitched together. A traction string catching the inferior margin of the patella was brought out and fastened to the dressing. A month after, active mobility of the patella was evident. The weight-bearing power was excellent.

Another kineplastic cuff on the knee-joint was made by Dalla Vedova of Rome, in 1913, but the patient died after the operation from tubercular condition of the lungs.

Pieri (1917), with the idea of imparting movements of plantar flexion to the artificial foot, made an attempt to utilize the calf-muscles to build a motor in a case of amputation at the inferior third of the leg. At the time of publishing his paper, the case was too recent to allow conclusions to be drawn or to speak of functional results.

The few successful cases from the old literature and the rather large experience of Sauerbruch who, up to the time of his last paper, had applied the method in over fifty cases, show that all the theoretical objections made to the Vanghetti theories are groundless. The problem of the prothesis, moved voluntarily by the action of the muscles which are the physiological remnants of the amputated member, is no more a theory but a real fact.

The rather high number of unsuccessful cases must not be attributed to the method but to the fact that for so many years it has remained in the stage of experiment, and that no surgeon had the opportunity of having a great number of cases. The experience of the surgeons shows also that the difficulty in performing kineplastic operations is not in the forming of the loops or of the knobs, but in covering these parts with skin, especially at the site which must be used to transmit the contractions. The possibility of ulcerations, which are the cause of long and tedious healing, can be prevented only by the use of healthy skin which should be taken if necessary from another part of the body.

The fundamental form of motor called *knob* deserves special attention. It may be obtained with a rather simple operation at any level of an amputation stump. The places which give more facilities are those rich with tendons, as the tendons and the bone-eminences where they are attached offer an excellent material to form a knob; but the part used to transmit the motion to the prothesis (neck of the knob) does not give the same good hold as a loop. The first to apply this form of motor was De Francesco, who performed the operation above described. The inconvenience that he experienced in his cases was that the muscular retraction pulled the knob on the central bone, reducing the space where he had applied the padded ring. This can be prevented by the interposition of soft tissues between the bones. In such a way the operation becomes identical to the one made by Slawinski and can be used in all cases of long stumps of the arm and forearms. While in the transmission of the movements, according to operations of De Francesco, one utilizes the contraction of the muscles only in one sense, by attaching the prothesis to the head of the knob, one may obtain, by the antagonistic action of the extensor and flexor, a double motion. The action of such a movable stump becomes like that of a "double phalanx" (Vanghetti's expression) or like that of an "artificial carpus" (Pellegrini's expression) on which the artificial hand may be applied. In such a case Pellegrini proposes to adopt the same prothesis used by Delitala in the partial amputation of the hand in which the movement of the residual carpic bones are transmitted to the artificial fingers. Putti, in one of his cases, has shown how to form a double knob in a case of an old amputation of the arm.

INDICATIONS AND TECHNIC

Although an outline of the technic has already been given by reporting rather extensively several cases, I think that at the present it will be useful to clearly formulate a few principles for kineplastic operations.

The kineplastic method should be applied in any case of amputation provided that there are no contraindications either in the age or in the general condition of the patient. Such a rule is more strict in the amputation of the upper limb. Even if the surgeon for special circumstances is not in position to form plastic motor, he should look for the possibility of a future kineplastic, by adopting the principles of the *transitory operations,* so as to preserve the power of the muscles of the stump. It is necessary, from the clinical standpoint, to make a distinction between the traumatic and the non-traumatic cases, especially in regard to their possible application to war-wounds. In non-traumatic cases any method of forming plastic motors may be used, while in traumatic cases one should adopt the method to the special conditions caused by the injury.

Here are a few general rules which should be remembered:

1. The adopting of a very simple operative method in order to obtain *one* or *two* motors.

2. The saving, in dissecting a flap, of as much skin as possible but not sacrificing too much bone; whenever it is deemed necessary, a pedunculated flap of skin can be taken from another part of the body in preference to the shortening of the amputation stump.

3. The muscles must be so managed as to save their innervation and vessel supply for the obvious reason of preventing atrophy.

The applying of one method or another depends chiefly on the location of the amputation. In a region rich in tendons, tendon-loops should be the choice; knob may be used also by taking advantage of the tendons and their bone-insertion. Where there are no tendons the muscles offer an excellent material. By suturing a muscle or an entire muscular layer over itself at one or both sides of the member, one may obtain a *"muscular knob"* or a *"muscular pad"* (Sauerbruch). Several muscles should be selected and sutured together to form a motor, instead of using a single muscle or a single tendon.

In traumatic cases an attempt to obtain plastic motors should be made only when the surgeon is sure of the sterile condition of the operative field. Whenever such a condition is doubtful it is better to renounce any idea of primary kineplastic and prepare the part for a later operation. In such a preliminary operation, especially in shell wounds, one must be very economical in removing contused or damaged tissues. In an injury at the wrist-joint special attention must be directed to save every little piece of tissue that shows even a trace of vitality, as it will be found useful in future kineplastic. In cases where tendons have been exposed it is wise to leave them without

resecting, because if they are cut the muscles will undergo a further retraction, while if they are left untouched and allowed to be eliminated by a slow process of necrosis they will form strong adhesions to the terminal scar and be valuable material for "future secondary" operations.

The only experiences with primary kineplastic soon after a shell-wound, so far as I know at this time, are those of Pieri. Although, as above referred, his results have not been encouraging, I shall report the outline he gives for a primary kineplastic amputation. "In case that the injury has severed the hand at the wrist, the wound should be rectified, by removing the contused tissues, so as to give to the stump the appearance of a Celsus amputation (Fig. 12*a*). The plastic motors can now be obtained as follows: Two lateral incisions about six to eight centimetres at the ulnar and radial sides of the stump are carried to the bones, and an anterior and posterior flap is dissected. Then the bones are resected for about five centimetres (Fig. 12*b*). To obtain a couple of knobs, the edges of each skin incision will be sutured in each flap in a longitudinal direction (Fig. 12*c*). Such a method may be applied also in the amputation of the arm (Putti). To obtain a loop (Fig. 12*d*) the skin is sutured with the same principle, but the ends of the tendons are sutured together so as to form a stirrup over the section of the bones."

Transitory Kineplastic Amputations.—Such a title Vanghetti and his followers apply to those operations which are so performed as to allow an easy kineplastic operation in a second stage. These operations do not essentially differ from the common amputations, but they are so modified as to give the possibility of forming the attachment apt to transmit movement to the prothesis. The muscles of the opposite side of the limb are sutured over the section of the bones, or over the articular surface in order to keep the muscles from retraction (Fig. 10, schematic reproduction). The forming of an attachment or of a knob may be made at any time, even after many years. To facilitate the fixation of the tendons or muscles over the stump the natural grooves or the articular surfaces must be respected, or made deeper, or transformed to a tunnel by opposition of the bones. If the muscles are not long enough to be fixed over the stump one may excavate a tunnel through which they may be united. Pellegrini, in a recent paper, has outlined various schemes which show how to utilize or how to use a mobilized piece of bone as a pivot (Fig. 11). Even one single bone may be used to attach the muscles when the other bone must be made shorter on account of pathological conditions. With another operation an attachment is to be made, or by a bone resection a knob can be formed. In a case where the muscles were too short to be sutured over the section of the bones, Wierze-

jewski took advantage of strips of fascia taken from other parts of the body to form artificial tendons and to unite antagonistic muscles.

Kineplastic Transformation of Old Stumps.—Although the muscles of an amputation stump, made according to one of the classical methods, after a while lose their power of contraction by undergoing a more or less extensive atrophy, still many stumps keep a sufficient degree of nutrition to permit a successful formation of kineplastic motors. The first cases were those of De Francesco and Von Wreden. In taking into consideration such cases, the surgeon should form the motor according to the circumstances, by taking advantage of the muscles which have better kept their power.

Amputation of the Lower Limb.—In amputation at the ankle, the Codivilla operation may be taken as an example. In order to avoid the inconvenience that Putti experienced in his case, it would be better to form the anterior motor as a loop. But if the knob is preferred, it should be larger, and possibly with some bony inclusion according to the rules of free transplantation. For the amputation at the knee-joint a loop, made by suturing the extensor and the flexor tendons, keeping the patella in contact with the condyles, is the simplest operative method, as it has been successfully used by Putti. Besides, all the amputations at the superior third of the leg, as all the osteoplastic amputations at the knee-joint, may be used for kineplastic purposes by tunnelling the quadriceps tendon or the flexor muscles.

Dalla Vedova, in his operation, mobilized and transplanted on the cut surface of the femur (supracondyloid amputation) the *anterior surface of the condyles,* with their cartilaginous layer turned down. The patellar ligament was sutured to the flexor muscles behind, consequently the patella acquired a horizontal direction and could execute movements on the displaced condyles.

A movable kinematic cuff, with a simple muscular loop, may be obtained even in cases of supracondyloid amputation when the osteoplastic method cannot be used. In 1914, without having any intention of making a kineplastic motor, I performed a supracondyloid amputation of the femur in which, on account of a previous operation, no anterior flap was available. To cover the section of the femur, which was made just above the condyles (according to the aperiosteal method) and to have an eccentric scar, I was obliged to cut a very long posterior flap from the calf-muscles. As the anterior incision of the soft tissues was close to the superior border of the patella, I made a very exact suture of the posterior muscular flap to the quadriceps tendon. The cuff showed, a few weeks later, such extensive voluntary movements that it could have been easily capable of transmitting

motions to an artificial leg. Unfortunately, the patient refused any other operation and left the hospital.

With the exception of the Pieri case, there has been no application of the method for the amputation at the inferior third of the leg. As a method of election, Pieri proposes to use the gastrocnemius tendon to form a plastic motor and give plantar flexion to the artificial foot. It is worth while to consider this suggestion, as it can be the source of successful application. He describes the following operative plan: "Cutaneous incision to provide a wide, anterior-posterior-external flap, the basis to be an inch below the point where the bones will be sawed, the length a little more than the diameter of the leg. In this flap, a little behind the fibula, a longitudinal incision is made. The consequence will be the formation of two flaps, one anterior-external, containing the anterior muscles, and one posterior, containing the triceps. After the section of the deep muscular layers, the bones are sawed and the exterior flap is used to cover the bones. The posterior flap, by means of small incisions, will be fitted so as to completely cover the calf-muscles and the tendon. This will be subsequently fenestrated or transformed into a knob."

The forming of an attachment to transmit motions to the prothesis is a very important step of the operative technic. The difficulties and unsuccess of various surgeons has already been discussed. By imitating Ceci's operation, it would be wise to form the button-hole of the loop, in a second operation, as Alessandri proposed. Even in other types of operations, one should divide it into two stages, which would favor greatly the final result. One of the best ways to form the attachment is the tunnelling of the muscles: the steps of this operation are shown in Figs. 13–16. Another form of attachment is the infundibulum, which is made by an artificial intraflexion of the skin in the underlying tissues. I do not know if this form of attachment, devised by Vanghetti, has had any practical application.

After-care.—"To prevent the effect of the muscular retraction, one must substitute for the natural insertion of the muscles, a new one either inside or outside of the stump" (Vanghetti). The after-care should try to obviate the secondary retraction that takes place more or less slowly after the amputation and is due to the atrophy for lack of function. This retraction, while it does not prevent a certain degree of work of a well-formed motor, can greatly reduce its power of contraction. The postoperative care is capable of reducing the loss of function or of almost recuperating it. Plastic motors with an internal attachment to the bones do not require any immediate after-care, as any retraction is prevented, but the stump should

be massaged and cared for, until the secondary operation is performed. In forming tendinous loops or knobs, it is useful to take some measure against the retraction which is favored by the long healing period. The majority of surgeons have tried to keep the muscles under tension by securing the tendons with silk strings which were passed outside of the wound and fastened either to the dressing or to an extension apparatus. The strings were removed when the wound was strong enough to permit the executing of regular exercises. Another way to keep the muscles under tension is to apply along the stump stripes of adhesive plaster and make traction on them. Such a procedure has been also used by Stropeni and Pellegrini to form, without any operation, a knob at the end of amputation-stumps.

CONCLUSIONS

1. The kineplastic amputation (Vanghetti's method) is such a modification of the operative technic that it makes possible the transmission of voluntary movements to the prothesis, thus realizing a true vitalization of the amputated members.

2. This method should be applied whenever possible, especially in the amputation of the upper limb.

3. In performing amputation of the upper limb, one should always have in mind the possibility of a future kineplastic transformation of the stump.

4. Secondary kineplastic operation should be favored and possibly performed in institutions where at the same time the artificial member could be constructed and fitted.

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SPLINT FOR THE TREATMENT AND TRANSPORT OF CASES OF FRACTURE OF THE FEMUR

By James H. Stevens, M.D.
of Boston, Mass.

The treatment of fracture of the femur from a military standpoint is an entirely different procedure from the treatment of the same condition in civil life, because in military life the primal object of medical corps and of hospitals is not entirely humane but are maintained to hasten the return to active duty of men wounded and to conserve bodily function to the end that they may once again be of service to the military establishment. Other ends must be sacrificed to this one first great purpose, especially during a war of magnitude where conservation of man power will be, in the end, the deciding factor.

Imagine a soldier with a simple Colles' fracture of the wrist treated for from four to six weeks by the old method of retention splints, taken off once a week and no motion instituted at the wrist until the final removal of the splints. Some cases are so treated at the present time, resulting always in disability which lasts from six months to a year, when we know that, with immediate passive motion and with removal of the splints early, there should be few cases of Colles' fracture without full motion at the wrist in four weeks. In fact, the motion ought never to be lost even from the first. The treatment of fractured femurs cannot be expected to show such beautiful results as may be obtained in Colles' fractures, because of the forced immobilization and, second, because weight-bearing is a necessity and therefore firm union must result before such weight is allowed to fall upon the fractured member in order to prevent subsequent deformities, but there is little doubt that our main fault has been the use of retention apparatus extending over too long a period of time even in fracture of the femur. Treatment of fracture by the old method, straight position and weights pulling from the skin surface of the leg overcoming deformity and overriding only by partially paralyzing the muscles whose pull serve to perpetuate the deformities, causing injury to joint ligamentous structure by their long continued pull, especially at the knee, is to treat this form of fracture without any consideration for the anatomical structure of the thigh and leg and of the mechanical problem which is to be overcome. Undoubtedly we have had fair results in spite of our treatment because nature is, after all, the best reparative surgeon and it makes up for many of our shortcomings and with time corrects many of our mistakes.

In the proper treatment of fracture of the femur, with or without external wound or damage to soft tissue, there are many features to be considered; but they are not particularly complex; in fact, they are extremely simple. A fracture of the femur without impaction anywhere below the

trochanters presents the same problem whether just below the trochanters or lower down in the shaft. In a word, the fixation or stabilizing factor of the thigh has gone out of business, allowing the muscle pull to continue in the various directions exerted by these forces when the bone was intact and acted as a restraining or coördinating element upon that pull.

A fracture of any portion of this rigid shaft is influenced in position by the various pulls. First, the action of the gastrocnemii below acting on the lower end of the femur tends to pull the lower fragment backward. Second, the pull of the biceps and semitendinosus and semimembranosus tends to pull upward the lower fragment; the semitendinosus and the semimembranosus to a lesser extent also tending to rotate the lower fragment inward. Third, the action of the psoas and iliacus has a tendency to pull upward and inward the upper fragment and also to rotate the upper part outward. A certain amount of rotation outward of the upper fragment is present in every fracture below the insertion of the psoas and iliacus. The only muscles which could rotate it inward to oppose this pull would be the gluteus medius, and it does so to a slight extent, but not enough; the semitendinosus and semimembranosus have lost their ability to oppose this rotation outward of the upper fragment because of the solution of continuity of the bony shaft, and therefore are unable to exert any force upon the upper fragment rotating it inward. Fourth, the gluteus maximus would tend also to rotate the upper fragment outward should the solution of continuity be below its insertion into the femur. The rectus also helps the semitendinosus and semimembranosus and biceps to pull upward the lower fragments. Fifth, the adductors tend to pull the lower fragment inward and upward, but also to counteract the pull of the semitendinosus and semimembranosus tending to rotate the lower fragment inward unless the fracture is low down, when they tend to pull inward the upper fragment; but also assist all the other muscles in rotating it outward. Therefore, while we must consider the forces acting as dependents upon the position of the solution of continuity of the bone, in the main, we may say that the tendency is for the upper fragment to be pulled upward, flexed and outwardly rotated and the lower fragment to be pulled backward, inward and upward and if anything rotated inward.

Obviously, there remains only to be considered the proper position of the leg in order to overcome the pull of these different forces. Such a position is only to be obtained by flexion at both the knee and the hip. Flexion at the knee puts the gastrocnemii out of action and renders *nil* the backward pull upon the lower fragment. Flexion at the knee also puts out of action the tendency of the biceps and semimembranosus and semitendinosus to pull up the lower fragment and of the semitendinosus and semimembranosus to rotate inward the lower fragment.

Flexion at the hip renders *nil* the pull of the psoas and iliacus in its tendency to flex and rotate outward the upper fragment and vitiates the pull of all the gluteal muscles except the gluteus maximus. The pull of the

rectus goes out of action. The sartorius and gluteus medius are relaxed, the great thick band of fascia, or iliotibial band, is no longer tense. Remains only the quadratus, the gemelli, the obturator, externus and internus, all tending to rotate outward the upper fragment, and the upper fragment of such a fracture is always, in fact, rotated outward.

There is relaxation practically of all the muscle groups in the entire thigh and a much lighter weight will now serve to pull the broken femur into alignment and keep it there, and we have only to take into consideration this outward rotation and slightly rotate the leg and foot outward to meet the rotation in the upper fragment to secure perfect alignment. In certain cases a heavy weight attached to the leg in the straight position works, as seen in the Buck's extension and Hamilton long splint methods, or modification of it, but it works only when the weight is made heavy enough to overcome, after a time, the pull of these various muscles and practically paralyze them. It is a long time before they recover their tone. In cases where transport is not considered the Hodgen splint acts well, but after a few weeks, when change of position can be considered, especially because it is better to consider some motion to the knee as soon as this is feasible, there is no method of making this change without discarding the Hodgen and changing to an entirely different form of apparatus. After three weeks in the flexed position there is callus enough to hold the ends of the broken femur while we move the knee and lower it to a new position much less flexed, or even to the straight position with a weight attached to the foot for a moderate extension during several weeks longer. The movement at the knee at this time is advantageous, as most femur cases complain of the knee more than anything else because of the enforced immobilizing and the time of the weight extension which has pulled the ligamentous structure of the knee much too long and caused damage. With the Hodgen splint it is some proposition to make this change without entire relaxation of the pulling force and as yet we have not believed that this is advisable to do at such an early date. What can be done for these cases of fractured femurs which must be moved from place to place as must be done now that war has come with its multiplicities of problems of transportation?

With the splint which we have devised we believe we have simplified some of the problems of the treatment of the ordinary case of fracture of the femur and have also made provision for the treatment of these cases which will need to be transported to a base. The splint is made with two steel side-bars attached to a well padded ring which fits about the thigh high up. The padding is extra heavy and also extra padded with felt or sheet wadding when the ring comes into play as when it is used as a transport splint.

The ring is made of copper 1 inch in width by ⅛ inch in thickness, which allows it to be moulded to fit the points of pressure, and it is then heavily padded. The two side-bars are jointed near the ring to permit of changing the position of the bars, either angled or straight.

Swathes of cotton cloth hold the leg in place and may be made additionally secure if needed by the ordinary bandages. The special binders made for the splint if used instead of bandages are caught by flare side pieces bent back over each rod and pinned to the side. This arrangement allows the remaining tails to be strapped across the front of the leg. This is simple where for any reason frequent dressings are necessary. Three are usually

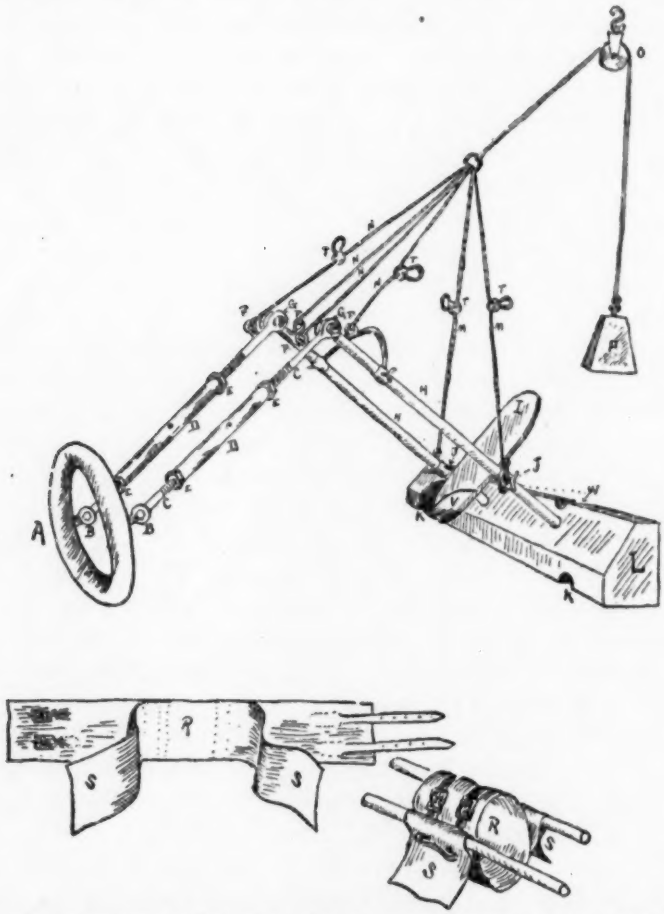


FIG. 1.—The Stevens femur splint. Three sizes of ring to each splint *A*, ring which is padded; *B*, joint of side-bar; *C*, side rod; *E*, check-nuts; *D*, turn-buckles; *F*, loop for cord; *G*, adj. joints; *H*, leg side-bars; *I*, adj. foot-piece; *J*, lock nuts; *K*, grooves for bars of a stretcher; *L*, matrix (wood); *M*, cord for support of leg; *N*, cord for extension; *O*, pulley; *P*, weight; *R*, canvas strip; *S*, side flaps to be pinned over side-bars, leaving ends of canvas strip free to be carried over front of leg; *T*, cord adjusters; *V*, heel rest; *W*, grooves in wooden rest for rods of splint when used in straight position.

enough for the support of the leg and two more for the thigh. On each side-bar is fitted a turn-buckle to be used always in transport and also in ordinary cases to give extra firmness to the extension, but in the treatment of these cases, not in transport, it is neither necessary nor advisable that there should be any pressure.

A foot-piece which is adjustable to any length of leg runs on the lower

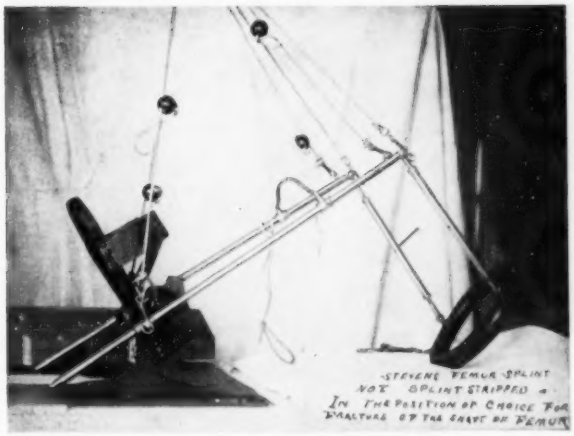


FIG. 2.

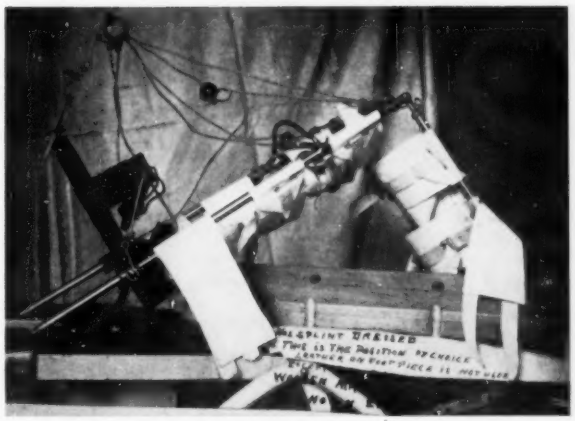


FIG. 3.

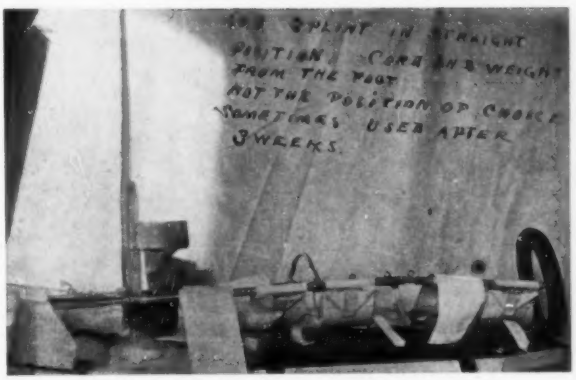


FIG. 4.

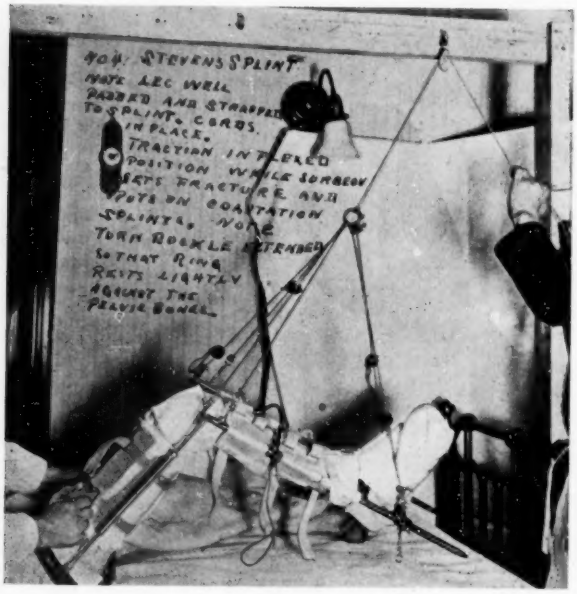

NO 4 STEVENS SPLINT
NOTE LEG WELL
PADDED AND STRAPPED
TO SPLINT. CORDS
IN PLACE.
TRACTION IN FLEXED
POSITION WHILE SURGEON
SETS FRACTURE AND
PUTS ON COAPTATION
SPLINTS. NOTE
TURN ANKLE EXTENDED
SO THAT RING
RESTS LIGHTLY
AGAINST THE
PELVIC BONES

FIG. 5.

NO 5 STEVENS SPLINT
DRESSING COMPLETED

FIG. 6.

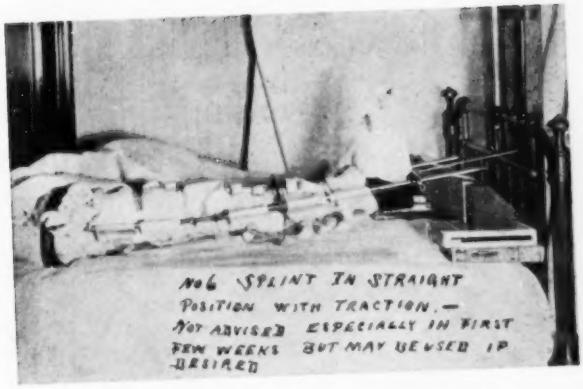


FIG. 7.

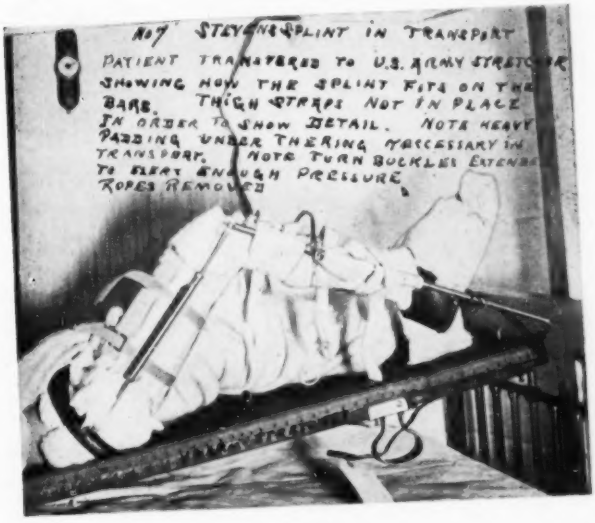

No 7 STEVENS SPLINT IN TRANSPORT
PATIENT TRANSFERRED TO U.S. ARMY STRETCHER
SHOWING HOW THE SPLINT FITS ON THE
BARS. THIGH STRAPS NOT IN PLACE
IN ORDER TO SHOW DETAIL. NOTE HEAVY
PADDING UNDER TIERING NECESSARY IN
TRANSPORT. NOTE TURN BUCKLES EXTENDED
TO GIVE ENOUGH PRESSURE
ROPES REMOVED

FIG. 8.

FIG. 9.

side-bars, and this foot-piece is padded to allow for the pressure of the foot and the inequalities of the dorsal surface of the foot. The splint is assembled. The leg with the broken femur is slipped through the padded ring until the ring rests upon the pubic bone and the tuberosity of the ischium. The foot-piece is adjusted and either strapped or bandaged to the foot, and the leg is firmly bandaged in place between the lower side-bars. With the leg strapped firmly to the splint and the foot to the foot-piece and ropes in place on the splint, the rope is carried over a pulley above the bed. The thigh is flexed at the hip and also to a right angle with the knee, and the rope entrusted to an assistant who exerts pull enough to reduce the fracture. Ether is seldom necessary. The fracture is manipulated by the surgeon and, if no external wound is present, a coaptation splint over padding is applied. With the pull still continued the turn-buckles on the thigh side-bars are extended so that the ring just touches the pubis, ischium and just below the anterior superior spine. The side straps are adjusted to fit the thigh in this position. A weight of 15 pounds is attached to the cord and the entire thigh and leg are left swinging clear. Ropes are so arranged that necessary amount of rotation is present and the proper arrangement of the turn-buckles assures 10 to 15 degrees of abduction, but this may be left to the individual surgeon.

Sometimes a scale is inserted in the pull to note the number of pounds which are necessary to swing the buttock just free of the bed, where one does not wish to use a pulley and weight. Where reduction of overlapping has not been accomplished in the first instance, as is possible in most cases with the thigh in this position, the pull of the rope above the knee exactly in line with the femur will in a short time, coupled with the perfect relaxation, suffice to pull the bones into alignment. The splint should be so arranged that the thigh is held slightly in abduction, which is essential. The foot of the bed is raised to counteract the continuous pull. In a few days all shortening is overcome and a new adjustment of the splint made by a turn or two of the turn-buckles to lengthen the splint but not enough to bring about any pressure on the pubic bone or tuberosity of the ischium. Should there arise the necessity of transporting this case before cured, the turn-buckles on the side-bars are turned to give extension after the check-nuts are loosened and the splint is extended between the thigh ring and the knee so that the femur is held rigid, the check-nuts are tightened and the splint is lowered to the bed. A piece of board two feet in length with perforations for the ends of the splint is provided to prevent rotation of the entire splint and leg while in transit.

Inversion or eversion of the foot is prevented by the foot-piece, and by raising or lowering either end of the wooden rest all rotation desired may be secured.

In transporting these cases the transport is made with the thigh in the position of flexion, holes in the matrix, or wooden rest, having been made to fit the handle bars of the stretcher.

From this he is transferred easily to the hospital train or boat and carried comfortably to his final destination, where he is again transferred to bed; the splint suspended, the pressure on the pubis and ischium released by a few turns of the side turn-buckle. Any dressing en route is easily made, in case of open wound, by simply unbuckling one or two straps, dressing the wound, and replacing them.

The pressure is, of course, against the pubic bone and the tuberosity of the ischium and also just below the anterior superior spinous process of the ilium in this flexed position, and too much extension must not be used. Neither is it advisable, necessary, or possible, to continue this form of extension for the entire treatment of the fracture, although a surprisingly low pressure suffices to keep the bone in place, once reduced. But this feature of the splint is solely a transport feature without necessitating a change of splint at any time, and the pressure of transportation could hardly be considered necessary for any considerable length of time. It would easily be borne without much discomfort for a number of days.

If the apparatus is used with weight extension the first weight should be 15 pounds and this increased or reduced as necessary; if used with scale, just sufficient to pull the patient's buttocks well off the bed.

In the suspended position, which should be the position of choice at least for the first weeks, the fracture if open is entirely accessible. The pull must be in line of the thigh and the foot of the bed raised to prevent the patient being pulled out of position.

After three weeks of suspension, soft callus is already formed and the leg may be (if wished) lowered to the straight position and extension made by attaching a rope to the lower side of the foot-piece and extension continued as long as desired, the foot-piece being allowed to slide on the bars in this position.

If desired, treatment may be instituted with this splint in the straight position and is simpler than the older methods, the extension being from the foot-piece, the foot-piece unlocked being left to slide upon the side-bars, and transport is rendered easy in this position by use of the turn-buckles, more force, however, being required than in the flexed position, because of the necessity of overcoming the muscle resistance. The base reached, the weight is again applied, still in the straight position, and treatment continued. The wooden cradle is used in this position to give the necessary rotation and to give firmness and stability to the apparatus.

HOSPITAL BED DESIGNED FOR MILITARY HOSPITALS

WITH A SPECIAL MODEL FOR CIVIL HOSPITALS

By Captain George W. Hawley, U.S.M.R.C.

CHIEF OF ORTHOPEDIC SERVICE, BASE HOSPITAL NO. 9 (NEW YORK HOSPITAL), A.E.F., FRANCE

A BED is simply a square frame with a more or less elastic surface supporting a mattress set on legs. The same is true of beds used for the sick and injured, but the ordinary bed is necessarily a heavy and awkward piece of furniture which does not lend itself readily to the demands of modern hospital treatment.

Every one appreciates the difficulties encountered in lifting serious cases in and out of bed, in transporting beds even on wheels, in securing elevation of the foot or head of the bed, in obtaining a satisfactory sitting or Fowler position, in applying artificial heat, in treating fractures, and in meeting many new conditions which constantly arise. The ordinary bed was not designed for such peculiar requirements, but for sleeping purposes only.

In the treatment of fractures where special apparatus and devices for traction are employed the inconveniences are especially obvious. In fact, the modern hospital bed should be a good deal more than a bed. It should be possible to transport bed and patient with ease, to place patients in various positions with little effort, to eliminate unnecessary handling of the sick, to save in the matter of labor with corresponding increase in efficiency and to provide more effective mechanical treatment for fractures. With the development of röntgenology, it should be possible to submit fractures to fluoroscopic examination in bed.

In military surgery the question of hospital beds is an important one. There is the matter of providing and transporting thousands of beds which take up considerable tonnage space. There is also the labor of installing this equipment, especially important where mobility is concerned, in mobile units when hospitals are bombed, or military necessity calls for change of location. Moreover, the hospital personnel is not only limited and labor must be utilized to the best advantage, but a great strain is put on the personnel when the wounded are received in large numbers at irregular intervals. There is always the danger of fire in the wooden barracks now generally used for military hospitals, and to remove bed-ridden patients, especially fracture cases, often tied to their beds, is a difficult undertaking. In a hospital with a thousand or more beds the labor of moving the wounded to and from operating room or Röntgen laboratory is very great. The seriously wounded require extra care. Fresh air treatment has been found most beneficial, but to lift patients out of bed and carry them out is a tedious process and often impossible in the fracture cases which need it the most.

FIG. 3

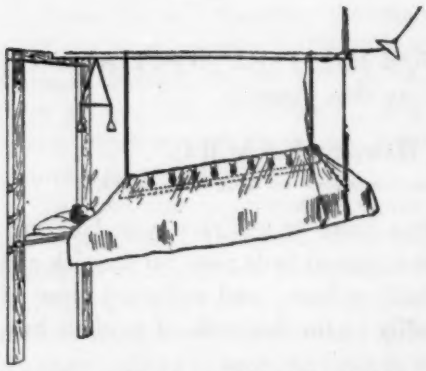


FIG. 4

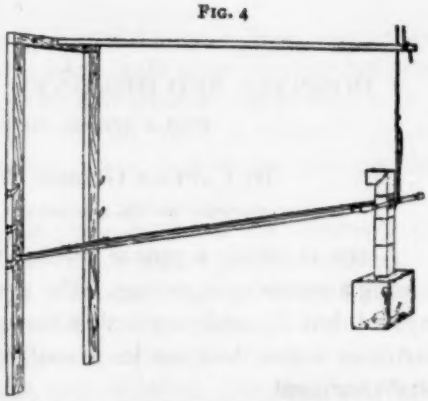


FIG. 3.—Showing method of using bed in cases of severe wounds associated with surgical shock. In many of the British and French hospitals, unusual attention is given these cases, a special "resuscitation" ward being set aside, and electrically heated beds used. Elevation of the foot of the bed, absolute rest and artificial heat are important factors in the treatment. Ordinarily elevation is obtained by placing various objects under the bed, but this entails a supply of numerous blocks and chairs, with which it is difficult to regulate or change the elevation and which encumber the floor. Electric heat is usually secured by means of a semicircular cradle lined with electric lights and resting on the bed. Considerable handling is usually required in moving these desperate cases from the ward to the operating room or X-ray laboratory. With this new type of bed the patient is moved without disturbing him in any way, elevation is obtained without floor supports and artificial heat supplied by a suspended tin reflector fitted with a row of electric lamps. This is easily adjusted as to distance from the mattress and gives unobstructed approach to the patient from either side for examination and treatment.

FIG. 4.—Bed showing artificial heat supplied by oil or alcohol lamp. It is customary when oil lamps are used to place them on boxes or stools, carrying the heated air through a small stovepipe up and under the bed clothes at the foot of the bed. This is rather clumsy in many ways. As a substitute a hanging stove has been devised which consists of a large tin box for the burner with a chimney made of discarded square tin cans. The stovepipe is suspended from the bed frame by strong hooks and maintained in the vertical position by being properly weighted below. As the foot of the bed is raised the chimney always remains in the vertical position and the lamp at the same distance from the bed. The pipe is carried inside the frame because the bed is extra long with an open space at the foot.

FIG. 5

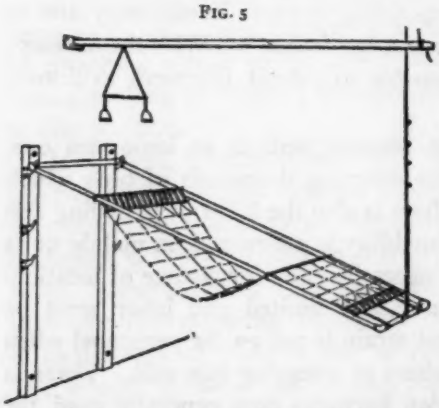


FIG. 6

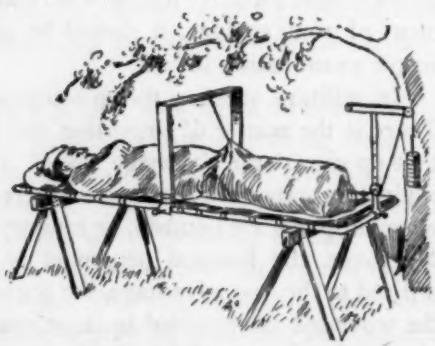


FIG. 5.—Bed showing Fowler position with head of frame raised and foot lowered. The sitting posture is obtained by having the row of coil springs at each end of wire mattress attached to two steel bars which in turn are secured to the ends of the frame by strong hooks. By placing another loose bar under the wire mattress at the bend of the knees and unhooking the upper bar, the mattress automatically assumes the position of a hammock chair. Both bars are held in place by small pins projecting from the side bars of the frame. The change to the horizontal position is made by lowering the head, raising the foot, and hooking the wire mattress over the upper end of the frame. This is accomplished by means of a simple lever. One distinct advantage of the sitting position as obtained by this bed is the fact that it has side bars which prevent the patient from falling out. With moribund, unconscious, and helpless patients it has not only been difficult to secure a satisfactory Fowler position, but it is often necessary to add lateral support.

FIG. 6.—Showing the ease with which patients may be taken out for fresh air treatment. Many cases of fracture with suppurating wounds are bedridden for months and are especially benefited by being taken out when the weather permits. It is a great advantage to be able to do this without moving the patient from the bed or disturbing the traction.

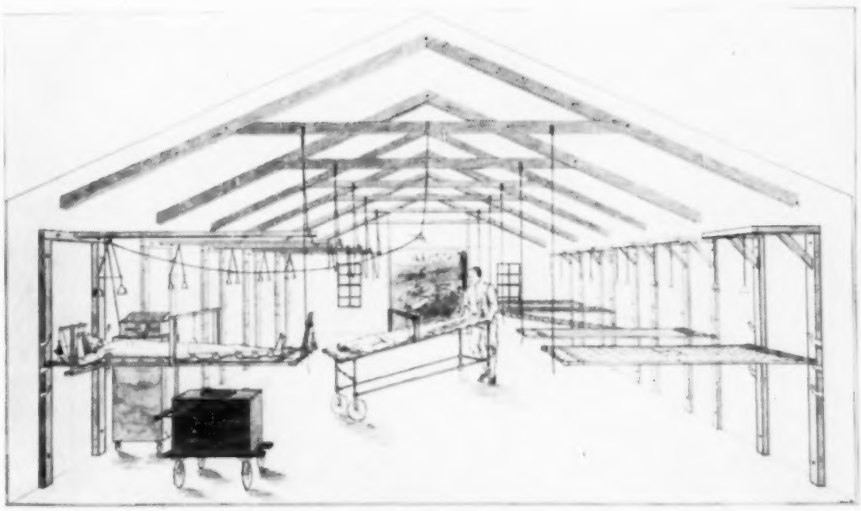


FIG. 1.—View of ward in "Santé" barrack showing new type of bed, which consists of a Bradford gaspipe frame secured at one end to wooden posts bolted to the wall and suspended at the foot by a rope to the rafter or ceiling. A set of iron hooks on the posts make it possible to raise or lower the head of the bed and a locking device holds the bed securely in place. The foot of the bed is elevated or lowered by means of the rope and a snap hook eliminates the use of knots and the danger of the rope slipping. Two forms of wooden frames are shown, but the more complicated one on the right has been abandoned. Both the wood and Bradford frames, being flat and light, are easily transported without crating, simply using the suspension ropes for tying the frames together in sets, and it is a simple matter either to install or take down the beds. Across the gaspipe frames may be stretched standard wire springs, canvas, or rope, as shown in the first three beds on the right. Mattresses made in two sections are used, so that one section may be removed for Röntgen examination. The floor space is entirely free and clear so that a portable X-ray tube stand may be wheeled under the beds, making X-ray examination in the wards, so much advocated by the French, quite simple. It also makes possible bedside fluoroscopy, so difficult on the ordinary bed, in the most advantageous position, from below, with unobstructed field for observation above the patient. A bar is hung over the bed from which are suspended handles by which the patient is able to lift himself, flasks for irrigation and Carrel treatment, electric bed warmers, etc. Supports for traction and suspension of the limbs in the treatment of fractures and wounds are attached directly to the Bradford frame. In this way the frame with the patient may be taken to the Röntgen laboratory, the operating room or out for fresh air treatment, without disturbing the limb or the traction. The beds are used to transfer patients from ward to operating room and from ward to ward. This saves the labor of lifting patients in and out of bed as well as much suffering and injury inflicted on serious cases. The wheel stretcher is simply rolled under the bed, taking bed and all, or the bed may be carried out by hand like a litter. In case of fire, a ward may be emptied very much quicker than when it is necessary to lift helpless patients from beds to litters, especially if encumbered with fracture apparatus or tied to the bed by weights and pulleys.

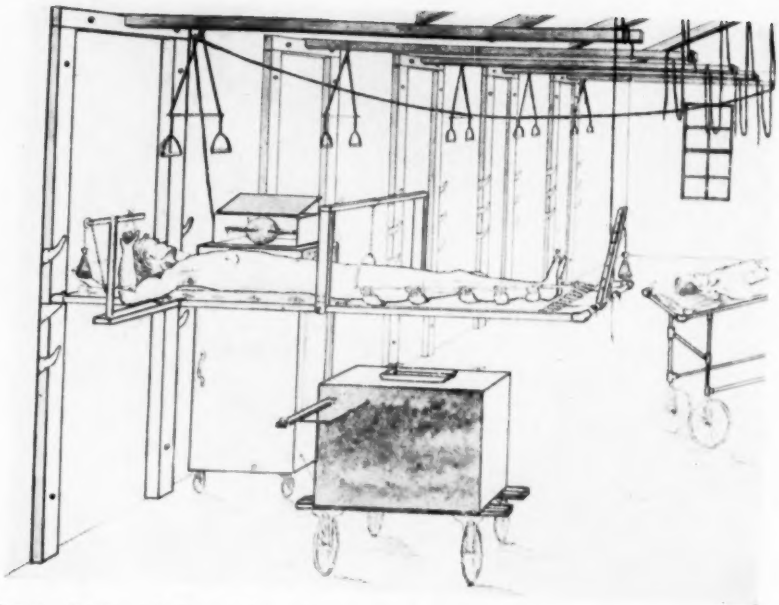


FIG. 2.—Section of Fig. 1, showing bed with attachments for fracture treatment and wheel trochoscope (designed by Capt. A. H. Busby, Chief of the Röntgen Laboratory, Base Hospital No. 9). The fracture attachments were designed by the author after an extensive experience in the treatment of military fractures among the French wounded, and have been fully described in a paper to be published at an early date. The idea has been to obtain effective fixation of the limbs in various positions with complete exposure for wound treatment, so essential in war fractures. Traction with suspension is secured with the Thomas splint, the Hodgens splint, the Balkan splint, with the Steinmann nail or the ice tongs, with the Finochietto stirrup, with the knee flexed, with the leg abducted, etc. In addition operation may be performed with the limb in traction and plaster cast applied upon the frame. A sling placed under the pelvis and fastened to the central bridge assists in the use of the bed pan and in the treatment of posterior wounds. The method of Röntgen examination in the ward, as planned by Capt. Busby, includes a portable Ledou-Lebard coil, which takes the current from the ordinary lighting system and the simple trochoscope for directing the rays from below. Ordinarily this will be sufficient for routine ward work. When, however, the lateral view is desired, it is only necessary to attach a special frame to the side of the trochoscope and adjust a separate tube which is carried for that purpose. Whenever advisable, the patient may, of course be taken to the laboratory.

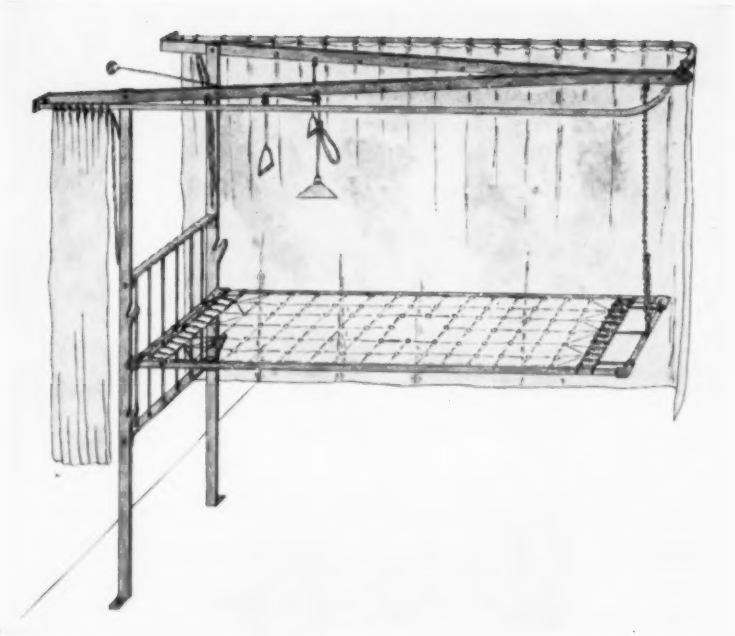
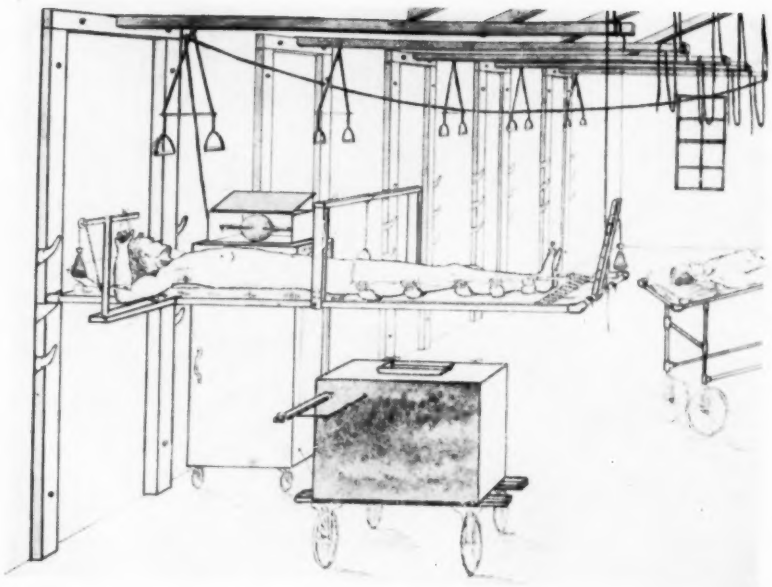


FIG. 9.—Special type of bed designed for civil hospitals. The Bradford frame is supported by two vertical posts set out from the wall and by a rope or chain suspended from two converging horizontal bars which are securely bolted to the wall and support the vertical posts. A separate curtain rod set well out from the sides of the bed support two curtains operated from the head of the bed, so that the patient may completely screen himself. A hole in the centre of the wire springs with a mattress in two sections may be utilized for special bedpan purposes. The open wire springs do not seriously interfere with horizontal fluoroscopy and if made of aluminum wire, the conditions for Röntgen examination of patients on the bed-frame are almost ideal. Holes in the bars over the bed provide convenient suspension for electric drop light, lifting handles for the patient, flasks for irrigation, Murphy drip, etc. A hinged, iron rod may be used to support the foot of the bed frame in place of the chain.



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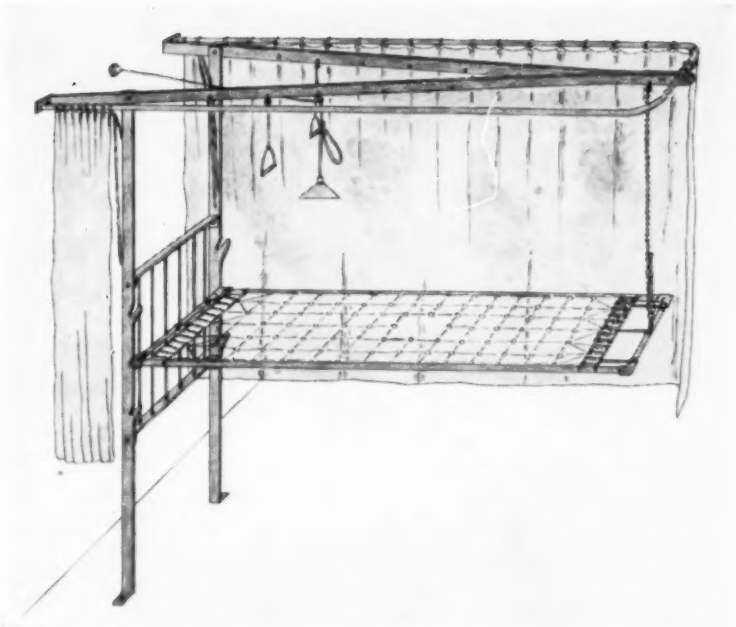

FIG. 9.—Special type of bed designed for civil hospitals. The Bradford frame is supported by two vertical posts set out from the wall and by a rope or chain suspended from two converging horizontal bars which are securely bolted to the wall and support the vertical posts. A separate curtain rod set well out from the sides of the bed support two curtains operated from the head of the bed, so that the patient may completely screen himself. A hole in the centre of the wire springs with a mattress in two sections may be utilized for special bedpan purposes. The open wire springs do not seriously interfere with horizontal fluoroscopy and if made of aluminum wire, the conditions for Röntgen examination of patients on the bed-frame are almost ideal. Holes in the bars over the bed provide convenient suspension for electric drop light, lifting handles for the patient, flasks for irrigation, Murphy drip, etc. A hinged, iron rod may be used to support the foot of the bed frame in place of the chain.

Following observations made in many French and British hospitals in 1916 and 1917, I have designed a new type of bed which Colonel F. A. Winter, Chief Surgeon, Lines of Communications, has authorized installed in one of the fracture wards of Base Hospital No. 9. The bed consists of an ordinary Bradford gaspipe frame which is supported at one end by posts bolted to the wall and by a rope suspended from

FIG. 7

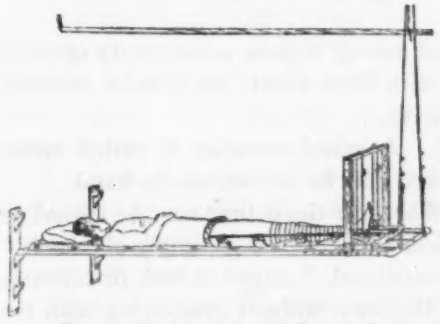

FIG. 8

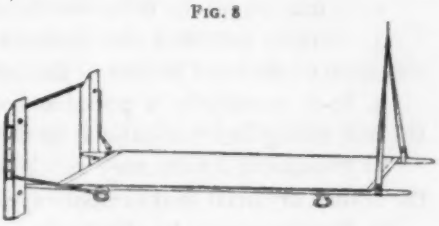

FIG. 7.—Showing bed with fracture bridge used to support the Thomas splint. This splint has become one of the most popular, especially among the British. It is particularly useful in the early treatment of fractures because early traction is very important and no other method relieves the pain so well. It is also valuable as a post-operative splint when cases must be evacuated to hospitals further from the front, and as a permanent splint when others are not available. This splint should always be suspended at the lower end when possible. A different form of wall bracket is shown, consisting of an iron plate with the hooks in one piece and a double rope at the foot of the frame. Simple beds constructed in this way would be suitable for the wards of civil hospitals.

FIG. 8.—Regulation army litter used as a bed. It has often been found necessary to equip barrack wards with stretchers instead of iron beds in emergency. These are usually placed on wooden horses, which in quantity are awkward to transport. By having a peculiar form of wooden cleats which bolt to the wall, it is possible to suspend litters in the same way as the Bradford frames, using the canvas carrying straps and a short piece of rope.

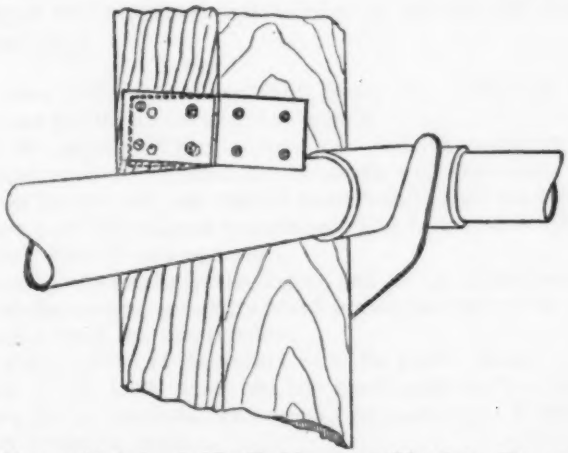

FIG. 10.—Ordinary hinge used to lock end of Bradford frame to wall brackets. These are put in on a slant so as to jam, making a tight fit.

the ceiling at the other end (Fig. 1). The head of the bed is adjusted in height by a series of hooks while the foot of the bed may be raised and lowered by means of a rope. A lock is provided for the head of the frame so that it is perfectly secure (Fig. 10). Standard wire mattresses, canvas or rope may be stretched across the bed frame. Fracture attachments for traction and suspension are fastened directly to the frame (Fig. 2). The wire or canvas mattress is arranged so that the Fowler position may be secured (Fig. 5). A horizontal bar above the bed supports lifting

handles for the patient, electric bed heaters, etc. (Fig. 3). The bed is six inches longer than the ordinary bed in order to give ample foot room for fracture cases. A special model of this type of bed is shown in Fig. 9, and a method for suspending the regular army stretcher for use as a bed is illustrated in Fig. 8.

The important features about this hanging bed without legs are:

1. It is simple, light and cheap.

2. It may be set up, taken down, and moved without unnecessary labor.

3. Various positions are obtained with little effort, the Fowler position, elevation of the head or foot of the bed, etc.

4. It is essentially a portable bed. A wheel-stretcher is rolled under the bed, taking bed and patient, or the bed may be carried out by hand.

5. It makes a satisfactory shock bed because the patient may be moved on the frame, artificial heat is easily applied, and elevation is simply obtained.

6. Fractures may be effectively immobilized, X-rayed in bed, or taken to the laboratory, the operating room or the lawn without interfering with the fixation of the limb.

7. The floor beneath the beds is free and clear, which makes it easier to keep the ward clean, and Röntgen examination at the bedside much simpler.

8. It is labor saving.

9. In case of fire patients may be removed quickly, each bed being taken out as a litter.

THE TYING OF A SURGICAL KNOT

By Arthur Rogers Grant, M.D.
of Utica, N. Y.

The prevalent manner of making a transfixion suture and knot if analyzed appears very crude. It is slow and clumsy. It is unskilful. It has no uniformity and therefore it is often a "granny" and frequently broken. It is extravagant. It is the probable origin of the occasional infection, gloves being the carrier.

I believe that a critical consideration of the faults of common practice is justified by the fact that every surgeon must use transfixion sutures constantly and therefore my new technic is an advantage, in every way, over the older methods.

The Old Way.—The nurse tries the tensile strength of the thread with her hands, threads the needle with her fingers and adjusts it in the needle-holder. The surgeon picks up a tissue forceps or needle forceps in his left hand and, taking the needle-holder in his right, transfixes the tissue with the needle and pulls it through. He then lays his needle-holder down near his right hand and his needle forceps near his left hand and picks up the ends of his suture and ties the knot; it is then cut off by the assistant. The surgeon then picks up his needle-holder and his needle forceps and adjusts them all in his hands again and repeats the procedure, laying them all down and picking them all up again.

A Better Technic.—The instrument nurse threads the needle with sterile forceps, not touching the gut nor the needle with her gloves.

Technic of the surgeon: Transfix the tissue, pull the needle through with the needle forceps and catch the suture near the needle with the needle forceps in the left hand; pull on the left end with the left hand forceps until the right short end is only one-half inch from the point of transfixion. The long end should be proximal and the short end distal to the operator.

Lay the point of the needle-holder across and on top of the suture just below the tips of the needle forceps, pointing *upward* toward the tips of the needle forceps, and make a loop around the needle-holder.

Now catch the short end of the suture with the needle-holder, keeping its tips close to the site of the knot, while the left hand pulls the first half of the knot tight. Now place tips of needle-holder *beneath* suture and make a second loop which completes a reef or square knot.

If a true surgeon's knot is required, make two turns of the suture in the beginning, after which the second turn is made as before.

The advantages of this knot are obvious:

1. The knot is visible in the making and, as the hands are not in the surgeon's view, slipping or loosening does not occur.

2. The two ends of the thread are in alignment, therefore breakage is almost eliminated because necessary tension can be most delicately estimated.

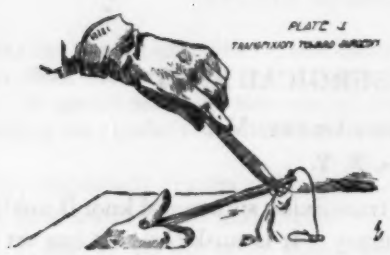

FIG. 1.

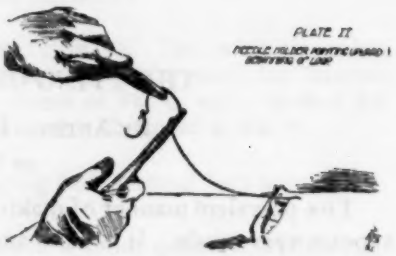

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7.

FIG. 8.

3. The directions of " first over then under " the thread, when the needle-holder makes the loop, always insures a square knot.

4. It is very smooth and once acquired makes a beautiful technic, because:

5. The instruments do not leave the surgeon's hands. Repeated interrupted sutures can be placed and tied without shifting.

6. And for the same reason it is a great time-saver without any semblance of hurry.

7. It is economical beyond belief; it is no exaggeration to state that one tube of catgut will tie as many knots as four tubes by the older methods.

8. It is universally applicable with any forceps, although I find that a Hagar or Ferguson type of needle-holder is best adapted. It is ideal when used with very fine sutures for the most delicate sutures in the eye, brain, etc.

9. Its placement in deep cavities is one of the most important features, because the short end, and the shorter the better, makes easy, important transfixion ligatures beneath the liver, in the depth of the pelvis and bladder, any place, in fact, where it is difficult to get a pair of big hands.

In placing sutures in very inaccessible regions a slight change in technic is advisable. Transfix tissue *away* from the surgeon so that when the ligature is drawn through the short end is proximal and the long end distal to the surgeon. Then make the first loop with the needle-holder ***underneath the*** suture; catch the short end with needle-holder and carry it down to, and then one-half inch distal to, the site of the knot.

Now hold needle-holder down firmly in this position and draw up as firmly with the long end: the ends are in alignment and the necessary opposing forces can be applied with the hands entirely outside the wound.

One could tie a safe knot by this method in the bottom of a bootleg.

10. "No-hand-touch technic."

When gloves were introduced it was believed that infection from hand contact would be eliminated. We know now that the gloves of surgeons and nurses are not always sterile at the close of operations.

While most catgut is above reproach, it is a good culture medium and many of the occasional infections come from handling of the strands by nurses or surgeons.

This method of tying knots furnishes a practical method of applying a " No-hand-touch " technic that is obligatory in many procedures.

After four years' experience with it in all varieties of general surgery I am sure that it is a refinement and an improvement upon older methods.

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THE BIOLOGICAL AND CLINICAL EVIDENCE OF THE THERAPEUTIC VALUE OF RADIUM AND RÖNTGEN RAYS IN CANCER*

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and

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In a recent publication Isaac Levin and Barnet Joseph (*J. A. M. A.*, 1917, lxix, 1068) reported on a series of cases of carcinoma treated by radium and Röntgen rays in which a clinical arrest of the disease was accompanied by a complete absence of morphologic changes in the tumor tissue. The writers explained this phenomenon by the assumption that the radium and Röntgen rays may impair the proliferating power of the cancer-cells and consequently the clinical malignancy of the tumor without producing any change in the morphologic appearance of the latter. They maintain that it is probable that the first effect of the rays on every malignant tumor consists in the inhibition of the proliferating power, in the *sterilization*, as it were, of the cancer-cells. The degeneration and destruction of the cancer-cells and the formation of the sclerotic connective tissue takes place subsequently, under the influence of the rays. The writers further assert that the degeneration and death of the cancer-cell may not be directly due to the action of the rays, but may take place in the natural course of the life cycle of the cancer-cell. This cycle consists in every plant and animal cell of *youth*, or period of development; *maturity*, or period of function; and the *senility*, or period of degeneration, which gradually leads to death. In normal cells of parenchymatous organs, like the liver or kidney, the first period is usually completed during embryonic life of the organism or at a very early age; the second period continues through the whole life of the organism, and the third period is attained at its old age or near its death.

The life of an individual cancer-cell is short. It changes rapidly from an embryonic into an adult and immediately into an aged, degenerated cell, and this process takes place continually irrespective of any extrinsic aid. But as a rule the cancer-cells are rejuvenated before they reach senility. The reason for it lies in the fact that each cancer-cell divides into two daughter cells, before the original mother cell reaches its maturity. When the

*Read before the Surgical Section of the New York Academy of Medicine, December 7, 1917.

rays arrest this proliferation, then each individual cancer-cell without any further outside aid matures, degenerates, and ultimately dies.

There is ample clinical and experimental evidence of the fact that the radium and Röntgen rays produce a direct inhibitory action on a certain class of cells. Moreover, the rays, when a correct quantity and quality is selected, may affect deeply one class of cells and produce no influence whatever on all other cells of the organism. The specific action of the rays on the testicles and ovaries is characteristic of such a direct influence of the rays on a certain class of cells.

Malignant tumors of vertebrates and man, on the other hand, are complex structures consisting besides the tumor-cells of connective-tissue stroma and blood- and lymph-vessels, and the mechanism of the action of radiations on cancer can therefore not be determined with certainty. Some observers maintain that the extensive formation of sclerotic connective tissue which is the generally observed change in tumor-tissue under the influence of radiation is its only direct effect. In accordance with this opinion, the destruction of the tumor-cells is secondary and due to lack of nutrition, and the rays exert no direct influence on the cancer-cells. In view of this complexity of the phenomena in human cancer it seemed desirable to study the effect of the rays on conditions analogous to human cancer but more simply constructed. The crown gall seemed to the writers to be an ideal structure for this purpose, and the present publication is based on a study of the influence of Röntgen rays on the development of the crown gall.

Crown gall is a tumor-like formation found on a great variety of plants. The name "crown gall" is given to the condition because the growth frequently appears on the part of a plant where stem and root join, which is called the crown of a plant. The disease is caused by a parasite (Bacterium tumefaciens) and may be induced artificially by inoculating the plant with a pure agar culture of the microörganism. Fig. 1 shows a crown gall on the lower part of a ricinus plant artificially produced by the writers. The technic consists in pricking the plant with a needle loaded with a drop from an agar culture of the Bacterium tumefaciens. For this inoculation as well as all of the present study ricinus plants and agar subcultures of Bacterium tumefaciens were used. The seeds for the former and the primary culture for the latter were obtained through the courtesy of Dr. Erwin F. Smith, of Washington.

Doctor Smith, who studied the condition continually for the last ten years, is of the opinion that the disease is completely identical with animal and human cancer. Moreover, from the fact that crown gall is a parasitic disease he deduces the theory that animal cancer is also a parasitic disease.

It is outside of the scope of the present article to discuss the reasonings of Doctor Smith and compare them with the viewpoints of pathologists and workers in cancer research. But nobody can deny that there is a nearly complete analogy between the two conditions. Crown gall as well as cancer is a new growth caused by a continuous limitless proliferation of a

group of cells within a tissue, the normal cells of which ordinarily do not proliferate. As a result of the rapid proliferation the new cells remain young and undifferentiated. Fig. 2 represents a microphotograph of a crown gall developed subsequently to an inoculation of an agar culture in a ricinus plant done by the writers. The tumor developed and grew within the stem cells of the plant. One notices that the cells of the gall are much smaller and richer in protoplasm than the normal cells of the stem. Thus, the basic structural unit of the crown gall, its proliferating cell, behaves in every respect in the identical manner as a cancer-cell. The fact, on the other hand, that plants do not possess any true blood or lymph circulatory system simplifies the structure of this type of growth. The crown gall practically consists only of tumor-cells and therefore, as stated above, presents an ideal subject for the study of the direct biological action of the Röntgen rays on tumor-cells.

The method of raying the plants was identical with the technic described by the senior writer in "X-ray Therapy of Human Cancer" (Isaac Levin, *Medical Record,* December 9, 1916). A preliminary set of experiments has shown that with this technic normal plants were not disturbed by the X-rays in their growth and development. Fig. 3 shows two ricinus plants of the same age and grown under exactly identical conditions of light, temperature and soil. The plants look nearly alike, though one was rayed and the other not. Preliminary inoculations by the writers with the Bacterium tumefaciens of a large number of ricinus plants have also shown that the inoculations were uniformly successful and were followed by the development of a large crown gall.

For the study of the influence of the Röntgen rays on the development and growth of the crown gall 43 plants were inoculated with the microörganism, and the inoculation was followed immediately by Röntgen ray treatment. The treatment was given to each plant 6 times in the course of two weeks at intervals of two days. Simultaneously with the radiated plants control plants of the same age and size were inoculated with the microorganism from the same subculture. Four weeks after the inoculation a final examination was made of the plants and tissue taken for microscopical examination. At that time all the control plants had developed a large crown gall. The majority of the radiated plants, on the other hand, either showed no trace of the inoculation, or a minute swelling appeared at the place of inoculation. Fig. 4 shows a control plant with a fully developed crown gall and a radiated plant with a minute swelling.

In ten of the radiated plants there developed a small stunted growth. Fig. 5 shows such a growth. The microscopical study of the radiated plants revealed an extremely instructive condition. Not only the stunted growths, but even the minute swellings which on gross inspection were thought by the writers to be scars caused by the mechanical injury of the needle prick, showed the presence of morphologically unchanged crown gall cells.

FIG. 1.—Two ricinus plants. *a* shows a crown gall in the lower part of the stem.

FIG. 2.—Microphotograph of a crown gall. *a* shows tumor cells; *b*, normal stem cells.

FIG. 3.—To the left an X-rayed plant; to the right, a control plant. Both plants normal.

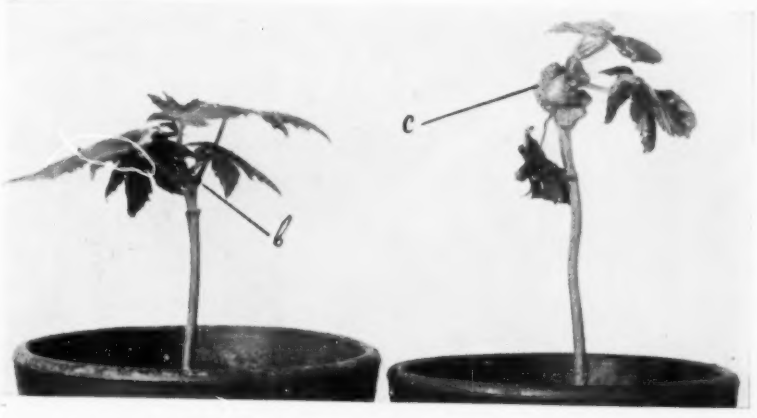

FIG. 4.—To the left an inoculated and X-rayed plant showing at *b* a minute swelling at the point of inoculation; to the right an inoculated control plant showing at *c* a fully developed crown gall. The plants themselves show no abnormality.

FIG. 5.—An inoculated and X-rayed plant; shows at *b* a stunted crown gall.

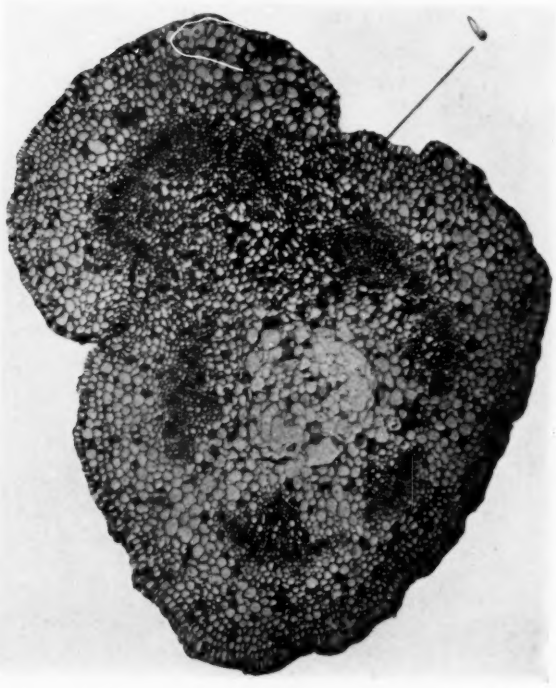

FIG. 6.—Microphotograph of a cross-section of a petiole. Shows at *b* a small group of tumor-cells.

Fig. 6 shows a microphotograph of a cross-section of a petiole (stem of a leaf) at the level of a swelling. It contains a small group of characteristic gall-cells. This finding clearly corroborates experimentally the opinion of Levin and Joseph stated above that the primary effect of the radium and Röntgen rays on malignant tumors consists in the inhibition of the proliferating power of the tumor-cells and not in their direct destruction.

In the present experiments this mechanism appears as the only possible mode of action. The raying was begun immediately upon inoculation with the express purpose of studying the action of the rays on the microörganism itself. It is evident that the rays did not destroy it, since it was able after the raying to alter a certain group of normal cells of the stem into gall-cells. Then under the influence of the rays these few tumor-cells did not proliferate and develop into a full-grown crown gall.

The results of the present experimental study as well as the clinical investigation of Levin and Joseph prove that the morphologic appearance of radiated tumor-tissue is not an absolute criterion of the therapeutic effect produced by the action of the rays on the tumor. The biolgical or clinical evidence of the arrest of growth or diminution of the size of the tumor is of undoubted value. A complete destruction of the tumor-cells which takes place in many cases even in large tumor masses presents undoubtedly the most perfect result of radiotherapy. On the other hand, negative morphologic findings do not preclude the possibility that the tumor was influenced by the rays. Radiated and non-radiated carcinoma tissue may have the same microscopic appearance, and still the former tissue is sterilized and may have lost to a great extent its power of proliferation and consequently its clinical malignancy.

The practical conclusion to be derived from these clinical and experimental investigations is the following: It is advisable to radiate malignant tumors not only after an operation, but in a certain class of cases also before an operation so as to sterilize and inhibit the proliferation of those cancer-cells which may be left behind or transplanted elsewhere in the course of an operation. Such a procedure does not prolong appreciably the time preparatory to an operation and presents no danger to the patient. The fear expressed by some clinicians that the raying may occasionally irritate and increase the rate of growth of the tumor is unfounded. There is no clear experimental evidence of such irritating action of the rays on young proliferating cells. The result is always an inhibition. The clinical evidence of the existence of an irritating action of the rays is also very vague and not convincing. One must keep clearly in mind the fact that any malignant tumor may suddenly increase its rate of growth and consequent malignancy without any relation to the instituted mode of treatment. In a series of 20 cases of carcinoma of the rectum which is being prepared for publication *in extenso* by the senior writer the following observation was made. In the cases in which an attempt at a radical operation was made the condition recurred with greater rapidity and malignancy than in those cases in which

there was no operation done and only radium and Röntgen ray treatment given or an exploratory was done followed by radiations. Similar observations are surely made by any surgeon with a large cancer material. In this series of cases the malignant recrudescence of the disease was not caused by the operative interference, but accidentally took place after the operation. The same holds true of the recrudescences which occasionally may take place after radium or Röntgen ray treatment, thus pre- and post-operative radiations of cancer as a method of inhibiting the proliferating power and the consequent clinical malignancy of the tumor-cells is of undoubted value and presents no danger.

CONSERVATION OF THE THYROID IN HYPERTHYROIDISM*

By John Rogers, M.D.
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This is a plea for conservation rather than radical or destructive thyroid surgery. It is based upon operative experiences with 478 cases of thyroid abnormalities. Of these, 296 individuals presented the symptoms commonly accepted as those of hyperthyroidism, and were treated by the ligation of two or more thyroid vessels. In nearly every instance the operation was supplemented by organ feeding with preparations from some endocrine gland, generally the adrenal or the thyroid. Exophthalmos of one or both eyes was present in addition to the other evidences of hyperthyroidism in 169 individuals. These patients were treated by the ligation of all four of the chief thyroid vessels.

As the direct result of these 296 ligation operations there were 9 deaths, or a mortality of 3 per cent. One of these, apparently in good condition, on getting out of bed on the sixth day, died very suddenly from unknown causes; but the other eight perished from the usual "post-operative hyperthyroidism." It is decidedly worth noting that all of these fatal cases showed a more or less pronounced degree of exophthalmos, and all but three of the nine died after the ligation of one or two vessels. These six fatalities occurred early in my experience and followed attempts to check a more or less rapidly advancing hyperthyroidism. Evidently, as others have observed, it is not good judgment to interfere surgically during an exacerbation of this disease.

Of the 160 who recovered, the present condition of 128 has been ascertained: 102, or 70 per cent., can be safely called cured; 18, or 14 per cent., are "improved," and 8 are unimproved. Nearly all of the 26 who were not cured were poor hospital patients who could not long be kept under the all-important after-treatment of rest and organ therapy. So far as can be ascertained, none of the patients who have survived this quadruple ligation operation for hyperthyroidism have later suffered from any intensification of the disease or from myxœdema. Some relapses have occurred, but with very few exceptions they have been again "cured" by rest and organ therapy. One case relapsed several times after hard night work, and recovered several times, and finally lobectomy was performed, but I have lately heard she has again relapsed.

There is no doubt that in suitable cases perfect results can be obtained by excision of greater or less amounts of the thyroid gland, and it would be foolish to condemn that operation. But the statistics of partial thyroidectomy show about 20 per cent. or 25 per cent. of failures to cure hyper-

* Read before the New York Surgical Society, February 27, 1918.

thyroidism, in addition to a mortality which, even in the most experienced hands, is somewhere between 5 per cent. and 10 per cent.

In an attempt to improve upon these results, and as an aid in the selection of the cases, because partial thyroidectomy is essential for the cure of some, I have been guided by a hypothesis which assumes a close relationship in the causation and pathological physiology of all types of thyroid abnormalities. Clinically, these disorders seem interchangeable, and the same patient may at one period show the signs of hypo- and at another hyperthyroidism. Or one with a simple, which means an otherwise symptomless, goitre may later develop myxœdema or exophthalmic goitre. If, however, a sufficient number of individuals can be observed long enough, it is possible to trace more or less order in this confusion.

The Apparent Course of Thyroid Abnormalities.—Every kind of thyroid disorder seems to be preceded or accompanied by circumstances which manifestly or by inference involve the production and expenditure of energy and fatigue. There follows an enlargement of the gland, which is apparently an hypertrophy, to compensate for excessive demands upon the organ, or for demands which are greater than the organ of ordinary size can fulfil. From this first stage of simple (compensatory) hypertrophy, the condition may progress into (1) a quiescent "simple" goitre in which degeneration often takes place with the formation of cysts or tumors; or (2) into hypothyroidism and, with an intensification of these symptoms, into myxœdema, with or without atrophy of the goitre; or (3) into hypothyroidism of longer or shorter duration and then into hyperthyroidism, and finally into true exophthalmic goitre.

Symptoms.—The symptoms usually accepted as indicating hypo- or hyperfunctionation of the thyroid are, to a considerable extent, traceable to disturbances in the involuntary nervous system. This, it should be recalled, consists of two parts which, broadly speaking, seem to have somewhat opposing functions. One portion of this system is made up of a group of nerves sometimes called the "autonomic," which are in general stimulating or activating. These are the third, seventh, ninth, tenth and eleventh cranial nerves and the visceropelvic nerve. The other group consists of the cervical, thoracic and abdominal sympathetic nerves, which seem in general to inhibit or oppose the activating influence of the autonomic nerves. Every organ of the body, except, so far as is known, the brain, is supplied by a branch from each of these two groups of nerves, which thus appear to have much to do with coördinating the activities of the body.

The incipient first, or hypothyroid, stage of these disorders is marked by headache, dilated pupils, pallor, dry skin, a dry mouth, anorexia, gaseous indigestion and constipation, and a sense of weariness. The blood-pressure is regularly low. The diagnosis of hypothyroidism can only be established by the presence of a perceptible thyroid enlargement and a susceptibility to thyroid feeding. Without the "goitre," the condition is indistinguishable from general exhaustion or fatigue. Not infrequently these hypothyroid

patients complain bitterly of a sensation of compression or choking, or of actual pain in the region of the thyroid. This is relieved by rest and thyroid feeding, and intensified by nervous or physical effort. If the disturbance is to continue into the second, or hyperthyroid stage, the headaches and lassitude gradually disappear. The heart action becomes intermittently and then constantly rapid, and in the early stages often "thumps" or "pounds," and communicates its motion to the thorax. The eyes may show some lachrymation, and the mouth salivation. The skin is flushed and moist, the appetite is generally excessive and there is regularly more than one daily movement from the bowels. The nervous irritability and the tremor complete the picture ("vagotonic" type).

Later, or after weeks or months or years of hyperthyroidism, and in the mixed or irregular types of the disease, the flushed moist skin becomes pale or bronzed and dry, the overaction of the heart becomes merely a tachycardia, there is anorexia, gaseous indigestion and constipation ("sympathetecotonic" type). Exophthalmos may appear early or late or without any evidence of hyperthyroidism, and in recovery is generally the last symptom to subside.

It is generally agreed that the most positive evidence of hyperthyroidism is supplied by the calorimeter. But the means for applying this test are not readily available. An equally positive test is the histological examination of a section of the tissue which can be excised from the upper pole of the gland during the ligation of the superior vessels. If in a doubtful case this operation reveals no hyperthyroidism, no harm results.

When the symptoms are examined with reference to the involuntary nervous system, it will be noted that in the first or hypothyroid stage the involuntary nervous system gives no manifest signs except possibly that its autonomic or activating portion is inactive. During the early part of the next or hyperthyroid stage, the moist eyes and mouth, the flushed moist skin, the rather excessive appetite (gastric hunger contractions), the loose bowels, and the heaving rather than merely rapid heart action all point toward an excessive activity or activation of the autonomic or activating part of the involuntary nerves. Later in this stage, and in the irregular types of hyperthyroidism, the dry mouth and skin, the anorexia and constipation, and the commonly high blood-pressure and simple tachycardia all point toward a deficiency in the autonomic or activating nerves and a preponderance of impulses from the inhibitory or sympathetic system.

Physiology.—It has been quite definitely proved that the thyroid has much to do with the general process of oxidation. Hence the value of the calorimeter test in conditions of hyperthyroidism. The gland has also been proved by its effects upon the metamorphosis of the tadpole, and by clinical observations, to be of great importance in growth and development. There can be little doubt that it has some influence upon the functionation of almost every organ in the body, and this influence may be exerted through the involuntary nervous system. Extracts from the fresh pig thyroid gland have

been made under my direction with distilled water, with slightly alkaline normal salt solution and with alcohol. When tested upon dogs it has been found that the distilled water extract is inert, but that the alcoholic extract and the non-coagulable portion of the saline extract produce quite definite and immediate reactions. In brief, this material is vasodilating, it increases the vigor of both voluntary and involuntary muscular contractions, it is a stimulant to the secretory activity of the pancreas, and it increases gastric secretion and peristalsis. In the case of the stomach, this stimulant or activating influence can be prevented or arrested by the injection of either atropin, which paralyzes the terminal filaments of the vagus, or of adrenalin, which is believed to stimulate the sympathetic or opponent of the vagus.

In these experiments no material could be found which would produce any appreciable degree of tachycardia. Furthermore, no material could be isolated from the human pathological hyperthyroid glands removed at operation which would produce any reactions whatsoever. A few tests made with extracts from normal human glands, obtained at autopsy, acted with the same vigor as the pig extracts.[1] Hence, it looks as though the thyroid through its secretion activates or stimulates the autonomic or vagus group of nerves and not as is commonly believed the sympathetic. The hyperthyroid gland, on the other hand, seems inert. At least no material could be isolated from these pathological organs which would produce any reactions.

When these findings are compared with the symptoms of hyperthyroidism the results are rather suggestive. Apparently in the early part of this stage of the disease, as evidenced by the excessive activity of the autonomic nerves, there is a true superabundance of an approximately normal quality of thyroid secretion. This superabundance activates the autonomic group, and overpowers the opposing or inhibiting sympathetic, and thus, in part at least, causes the flushed and moist skin, the moist eyes and mouth, and the gastro-intestinal activity, and the heaving heart-beat (vagus stimulation?).

The cause of the tachycardia may thus not be the direct stimulation by the thyroid secretion of the cardia-accelerator nerve, but rather some response of the heart to the systemic needs for blood produced by the increased general metabolism.

As the disease continues, the evident excessive activity of the autonomic system disappears and is succeeded by an apparent excess or preponderance of sympathetic or inhibitory impulses.

It is legitimate, therefore, to infer that the thyroid first undergoes, in response to automatic impulses, a compensatory hypertrophy and then becomes fatigued and its secretion diminishes. A continuation of the fatigue in some way next impairs the quality but increases the quantity of the secretion, and hyperthyroidism appears. In course of time, the secretion gradually changes and becomes more or less inert. In the irregular types

[1] Amer. Journ. Physiol., vol. xxxvi, No. 2, Jan., 1915; vol. xxxvii, No. 3, June, 1915; vol. xxxix, No. 2, Dec., 1915; vol. xxxix, No. 3, Jan., 1916; vol. xl, No. 1, March, 1916.

of hyperthyroidism which from the outset have a preponderance of sympathetic nerve symptoms, the primary fault appears to be a poor quality of thyroid secretion. It is also worth noting that these atypical or "sympathetic" cases of hyperthyroidism are quite frequently benefited by thyroid feeding, while the "autonomic" group are always injured. Furthermore, the cases which do the best after the "radical" operation are always in the early or "autonomic" stage of the disease.

Treatment.—If the different thyroid disorders are related, as they seem to be, and run a more or less definite course which is regulated by fatigue, they should be prevented from progressing by thyroid feeding and by rest. That is, the common, simple hypertrophy which usually takes the form of a soft symmetrical enlargement of both lobes, should be regarded as compensatory to excessive demands upon a thyroid which in some instances at least may be congenitally weak. An enlargement of this kind should, of course, not be excised. The organism apparently needs more secretion than the thyroid of normal size can supply, and as fatigue intensifies and rest improves these conditions, thyroid feeding and mental and physical quietude should be instituted. If, however, the disturbance, even under the best of conditions, shows signs of advancing towards hyperthyroidism, surgery may become necessary.

As the impulses which cause the thyroid to hypertrophy and become fatigued and then overact are probably conveyed to the gland through the blood supply, it is logical to cut off some of the stimuli by ligating the vessels. It is not logical to resect the lobes. The decrease in the blood supply and the thyroid feeding by supplementing (?) the efforts of the gland can both be supposed to improve the functionation of the thyroid by affording it rest. When localized tumors develop, they presumably, at least, by pressure, interfere with the normal functionation of the adjoining healthy epithelium, and should therefore be excised or, more exactly, enucleated, in order to preserve as much as possible of the sound tissue. If, however, at any time the thyroid shows signs which indicate that it is compressing the trachea, it is, of course, necessary to remove enough of the gland to entirely relieve the pressure. This operation should also, as far as possible, be performed by the enucleation of cystic or adenomatous masses rather than by lobectomy. In addition to the obvious and often immediately dangerous mechanical interference with respiration in these cases, there may be some added difficulties (in the decreased air supply) which are connected with the oxidative function of the thyroid. At any rate, patients with goitres which compress the trachea seem prone to show symptoms of hyperthyroidism, and they cannot be relieved without at the same time relieving the tracheal stenosis.

After hyperthyroidism has become established, the cases can be classified for surgical treatment in two groups:

(1) Those in whom the removal of a greater or less amount of thyroid tissue, or lobectomy, offers the best outlook.

(2) Those in whom the ligation of all four (or fewer) of the thyroid vessels is preferable.

When there is a reasonable certainty that the disease is confined to one lobe or to a particular and recognizable portion of the gland, experience has abundantly proved that the removal of this abnormal part is very satisfactory. The recovery is usually prompt, and although a later recurrence or relapse is always possible, it is not probable. The localization of the diseased tissue, or of the histological changes which are characteristic of the hyperthyroid gland, apparently does not have to be exact or complete. As long as the major portion of the disease can be removed the prospects of cure seem good. This localization of the diseased process in one lobe or in one portion of the organ can be inferred from the comparative size and consistency and apparent vascularity of the different parts of the thyroid.

In my experience, the so-called radical operation, or excision of a greater or less amount of the gland, is liable to fail to cure, or to yield unsatisfactory results in the goitres which are symmetrically enlarged and of equal consistency and vascularity throughout. In these, every portion of the gland is probably involved, and the removal of one-half or more of the thyroid should leave the remainder as only less workable or less toxic than the entire organ. The *small,* symmetrically enlarged glands, accompanied by pronounced symptoms of hyperthyroidism, especially when the signs of sympathetic irritation preponderate and the blood-pressure is high, seem the most unfavorable for the radical operation of excision. On the other hand, the enucleation of a localized adenoma or cystadenoma in a gland which is causing hyperthyroid symptoms accompanied by high blood-pressure, has several times in my experience resulted in a most remarkable lowering of the arterial tension.

In all cases, therefore, in which the thyroid is symmetrically enlarged and of even consistency throughout or is presumably affected in all parts by the hyperthyroid changes, I advise the ligation of all four of the chief thyroid vessels. The operation should be performed under local and not general anæsthesia, and in two stages. The two lower arteries should be tied first, and it does not seem necessary to cut them. They are often large and rather deeply placed, and if the ligature slips, the difficulties in these nervous subjects may be considerable. During the recovery, there is an absence of the painful deglutition which always follows the ligation and division of the superior vessels. After the lower wound has healed, or a week later, the upper poles can be exposed through the usual transverse collar incision. The patient will then have shown some improvement and will better endure the subsequent discomfort. The inferior arteries are best exposed by a vertical three-inch incision along the lower end of the posterior border of the sternomastoid muscle. This generally crosses the external jugular vein, which will then have to be divided. The incision is deepened down to the outer border of the scalenus anticus. Then, mostly by blunt dissection, the loose cellular tissue in front of this muscle is sepa-

rated, the great vessels with the vagus nerve are drawn forward and the inferior thyroid artery felt or seen to the inner side of the scalenus anticus. It can thus be readily tied between a double ligature and cut, although the division does not seem necessary.

After this quadruple ligation operation for hyperthyroidism there is usually an immediate subjective improvement, but the tachycardia may not subside for a long time, or for months. The calorimeter test also shows that the increased metabolism disappears with equal slowness. Nevertheless, this operation, as shown above, has yielded most satisfactory results, both as regards mortality and perfect and permanent cures. It needs, however, to be supplemented, like any other treatment for hyperthyroidism, by good hygiene and rest and by organ therapy. During recovery the disease retrogresses through a longer or shorter stage of apparent hypothyroidism and often much relief can then be afforded by the cautious administration of small amounts of thyroid material.

MADDERIZED BONE AS A MATERIAL FOR BONE-GRAFTS

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The fate of bone transplanted into the osseous tissue of the same or another animal has long been a question of interest, but one not easy to decide, due to the difficulty of determining with certainty whether the material examined at some subsequent period was the original graft or new bone. Adopting the simple method of making the transplant absolutely recognizable months later by using well-stained madderized bone, and inserting it into the bone of an animal never fed madder, we were able to follow its subsequent history with ease.

The advantage possessed by madderized bone as graft material consists in the fact that its bright red color stands in sharp contrast to normal bone. The coloring agents which it contains, alizarin and purpurin, are united closely with the ordinary bone salts (Gottlieb,[1] Macklin[2]), so that madderized bone is not decolorized during the course of the animal's existence except as the bone salts themselves are removed. Furthermore, the bone stained in this way is absolutely non-toxic, and behaves exactly like normal unstained bone; like it being torn down in the course of osseous catabolism incident to development and to the wear and tear of ordinary life. These facts are quite apparent from the madder literature. Thus, madderized bone is simply ordinary living bone which is stained characteristically and permanently.

In order that the graft may be readily recognized, the madder staining should be intense and present throughout the bone. To satisfy these requirements the animal from which the insert is to be taken should be fed madder daily from a very early period of life, preferably from birth (Macklin[3]), and the feeding continued up to the time that the bone is removed. If the feeding is not begun early enough some of the original bone will remain unreplaced by madderized bone, and if madder feeding is discontinued for an interval before the graft material is used there will be new unstained bone deposited over the stained part. In either case the unstained bone of the graft would lead later to confusion with new bone deposited subsequent to transplantation.

Allowance must be made for variation in rate of absorption due to the age of the grafted animal. In a very young animal the bone resorption and growth is rapid, so that the transplant is soon absorbed and replaced with new bone in the normal processes of the animal's growth, whereas in an

older animal the resorption process is slower. This method is easily adaptable to a comparative study of resorption rates of grafts in animals of various ages.

It is essential, of course, that an animal be chosen which eats the dye-stuff readily. Not all animals do this, cats showing a marked aversion to the ground root, and dogs refusing it unless thoroughly mixed with meat. Rats, however, take the dye-stuff readily when intimately mixed with their ordinary food.

For the brief preliminary work here recorded rats were used, which were obtained from the excellent colony of the Wistar Institute, Philadelphia, where the experiments were conducted. Only transplantation into the flat bones of the skull was done. Specimens were examined in the fresh condition, after being cleared in oil of wintergreen by the method of Spalteholz [4] and after being sectioned.

The operations were conducted as follows: A trephine opening, 5 mm. in diameter, was cut through the parietal area of the unstained animal, and into this was placed a piece of bone obtained in a similar manner a few minutes before from an animal which had been fed madder for a period so long that the entire bone was stained. The wound was then closed, and the animal kept on the ordinary diet of table scrap till death. Two animals were thus treated. One was sacrificed fifty-one days after operation; the second after five months.

In both cases the skull showed the madder transplants still in place. In the cleared specimens the picture is most striking, the bright red insert standing out in sharp contrast to the colorless surrounding area. It is easy to see that the insert has been revascularized and apparently permanently welded into place in the skull by unstained callus. There has been some bone erosion at the edges of the insert, as well as at the outer edges of the opening in the skull of the grafted animal. In places in the graft, too, the red bone has been replaced by new uncolored bone, so that some wearing away of the transplant has occurred. It is noteworthy, however, that so much of it remains, even at the end of five months.

Much of the material resorbed was doubtless bone injured by the trauma, and it may be that aside from this the erosive processes occurring in the graft were merely those common to the skull as a whole, in the course of everyday metabolism. Indeed, these findings suggest that the foreign bone has not merely served as a framework on which osteoblasts might erect a totally new structure, it itself being resorbed simultaneously with the laying-down of the new bone, but that it has actually become incorporated into the living bone about it, and will undergo resorption only as this process is carried out on the rest of the skull with the normal metabolic processes.

While the observations here recorded are limited, we believe the method contains possibilities which will make it of value in tracing the fate not only of living bone grafts, but also of dead ones, for madderized bone of the type described can easily be killed by boiling, and then inserted. Although the

long bones of the rat are rather too small to be conveniently handled as bone grafts, those of a larger animal, such as the pig, could be easily employed in this way.

There is one disadvantage in this method. The process of decalcification brings about an almost complete decolorization of the bone on account of the fact that the principal dye-stuff of madder, alizarin, loses its color in an acid medium. Gottlieb [1] asserts that a little of the staining remains after immersion in the acid, and we have found that this is true with intensely stained bones, but the coloration is so faint as to be indistinguishable in sections of ordinary thickness. However, the finer details may be studied in sawn and polished sections, or in thin slabs of bone cleared by the method of Spalteholz.

The converse of this course may also be followed; after an unstained graft has been transplanted into the bone of an unstained adult animal the latter is put upon a madder diet until killed, with the result that all the new bone subsequently deposited is colored red. Thus, if the graft be substituted by new bone it would be possible to observe the rapidity of its displacement by noting the progressive increase of new red bone in a series of cases.

Any new bone laid down in the course of metabolism would also be colored, and by comparing the amount of this with the amount of bone replacing the graft it would be possible to say whether or not the deposition of new bone in the graft exceeded that in other areas of the body, and thus whether the graft was being substituted in the course of normal osseous catabolism or by a special erosive process.

NOTE.—Our attention has been called to a somewhat similar method of bone staining used by Barney Brooks and reported in the June, 1917, and December, 1917, numbers of this Journal (vol. lxv, p. 704, and vol. lxvi, p. 625). These articles were unknown to us at the time of writing. Our work was done in the summer of 1916, at the Wistar Institute, Philadelphia, and the specimens were demonstrated at the meeting of the American Association of Anatomists in New York, December 28, 1916.—M. D. T. and C. C. M.

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THE USE OF SMALL BONE TRANSPLANTS IN BRIDGING A BONE DEFECT

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In certain types of fractures of one of the bones of the forearm where there is malunion with loss of substance it is frequently difficult to properly brace the resulting defect. The bone is too small to maintain a transplant in position by the use of a Lane plate or other device; and the insertion of an intramedullary splint with a dowel is a procedure of considerable difficulty and requires a large exposure of the fractured bone. In performing bone transplant operations in dogs while pursuing the study of bone repair the writer was struck with the universally good results obtained by transplanting small bone fragments, 1–2 mm. in size, to fill a defect in the shaft of the radius. Although this study is purely an experimental one, it is reasonable to assume from the results obtained that it will be of distinct clinical value in well selected cases.

Description of a Typical Animal Experiment.—Under ether anæsthesia the radius is exposed for a distance of at least 4 cm., the surrounding structures are dissected free from the shaft and a portion of the shaft about 3 cm. long is removed. The periosteum is excised for a distance of 1–2 cm. from both cut ends of the radius. The excised piece is now freed of its periosteum, it is split lengthwise and all visible endosteum is removed. Following this it is cut into small fragments 1–2 mm. in size, and these little fragments are inserted into the bone defect (see Fig. 1). The muscle, fascia, and skin are closed in layers; a gauze dressing followed by a plaster-of-Paris bandage is applied.

At regular intervals following operation radiographs have been taken and the dogs sacrificed. The leg is then examined clinically and later decalcified and sections are made for microscopic examination.

Results.—Twenty-six dogs have been operated upon in the manner described above, of these two have become infected, two fractured the radius by jumping off elevations and angular union occurred. Of the remaining twenty-two good union has occurred in almost every case. This is remarkable, as it is impossible to immobilize the foreleg satisfactorily and the dogs use them from the very first day post-operative. The gross examination in the early stage reveals numerous irregularities of the bone; as time progresses, however, the rough areas are absorbed and the bone resumes its normal form. It is interesting to note that whenever a tendon is in close proximity to these fragments it eventually forms a depression such as normally occurs in the bicipital groove. In specimens one year after operation it is often difficult to find the location of the transplants.

Radiographic Findings.—In studying a series at intervals after operation it is seen that the transplants become gradually smaller while about them a formation of new bone occurs. At later stages the form and contour of the shaft is re-established. In two

instances where there has been clinical union a transverse line has been observed by X-ray (Figs. 12, 13, 14 and 15).

Microscopical sections taken from seven days to one and one-half years show that there are two main factors involved in the repair of these bone defects: Namely, first, the bone fragments, second, the organization of connective tissue about the fragments. Let us consider these two factors separately.

1. *The Transplanted Bone Fragments.*—In from ten to twenty days after operation the bone cells in the central portions of the fragments lose their standing reaction, while those at the periphery are still viable.

Immediately following transplantation clotted blood is seen in the Haversian canals with fibrin formation. In about four weeks blood-vessels containing normal appearing blood-cells are seen. It is difficult to determine whether the blood is re-established through the old vessels or new ones are formed. About these larger canals there appear two or three concentric layers of bone cells with normal staining nuclei. At the periphery of the fragments areas of rarefaction and areas of new bone formation occur (Fig. 7).

2. *The Connective Tissue About the Fragments.*—After the operation blood clot forms about the fragments, gluing them together; it becomes organized by granulation tissue; fibroblasts are seen growing in from the periphery and then young blood-vessels appear. As the granulation tissue becomes organized calcium salts are deposited in the perivascular areas forming a very definite new bone. A very low power microscopical picture of this connective tissue at this stage appears similar in design to an irregular lace curtain pattern, the dark staining areas which correspond to the web of the curtain consist of new bone, while the light staining areas are composed of blood-vessels and young connective tissue (Figs. 9 and 10).

At a later period these new bone areas increase in size at the expense of the young connective tissue, the latter gradually changing into fibrous connective tissue. Sections under high power show gradual graduations of the cellular elements; from connective tissue to bone, from connective tissue to fibrocartilage, and from fibrocartilage to bone.

As time progresses the bone fragments are gradually absorbed and lose their identity in the mass of new bone forming from connective tissue. In a year the medullary canal has been re-established and we have tubular bone which is difficult to distinguish from the normal shaft. The Haversian canals have reformed in the direction of the long axis of the shaft. The bone is covered with a connective tissue layer resembling periosteum (Fig. 5).

In the two or three cases where the X-ray showed an artificial joint we find that the adjacent bone surfaces are covered with cartilage and an adventitious joint has been formed (Fig. 4).

Too much importance has been placed by most authors upon the origin of the bone cell as the vital factor in bone repair. This has clouded our conception of the process. Bone is mesoblastic in origin, and in its repair we find that calcium salts are deposited on the intracellular elements of connec-

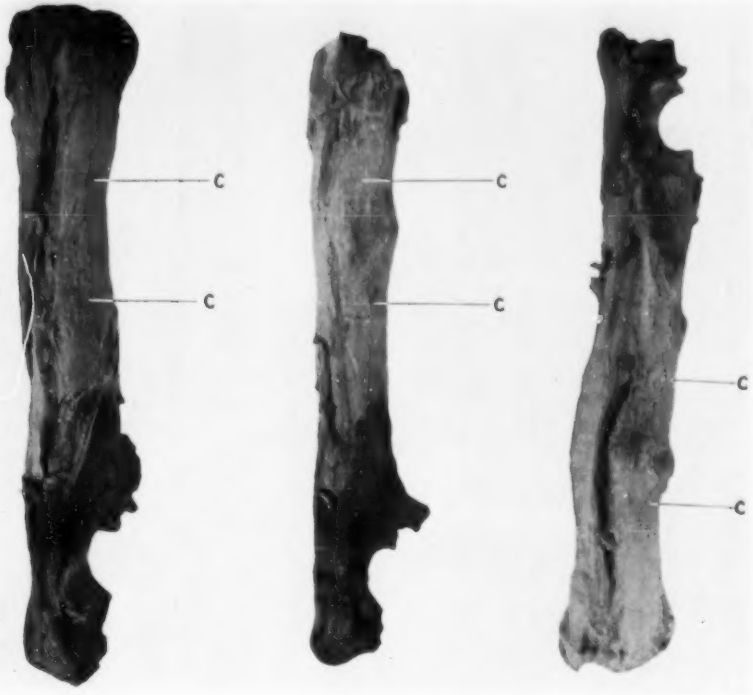

FIG. 1.—Showing how radial transplants have fused. *cc*, bone defect filled with transplants. *a*, duration, 332 days; *b*, duration, 163 days; *c*, duration, 271 days.

FIG. 2.—Duration, 4 days. Appearance of fragments soon after transplantation. They are surrounded by blood-clot.

FIG. 3.—Longitudinal microscopical section (low power). Duration, 46 days. *a*, ulna; *b*, radius; *cc*, fragments in radial defect. Rarefaction of fragments with new bone formation about them.

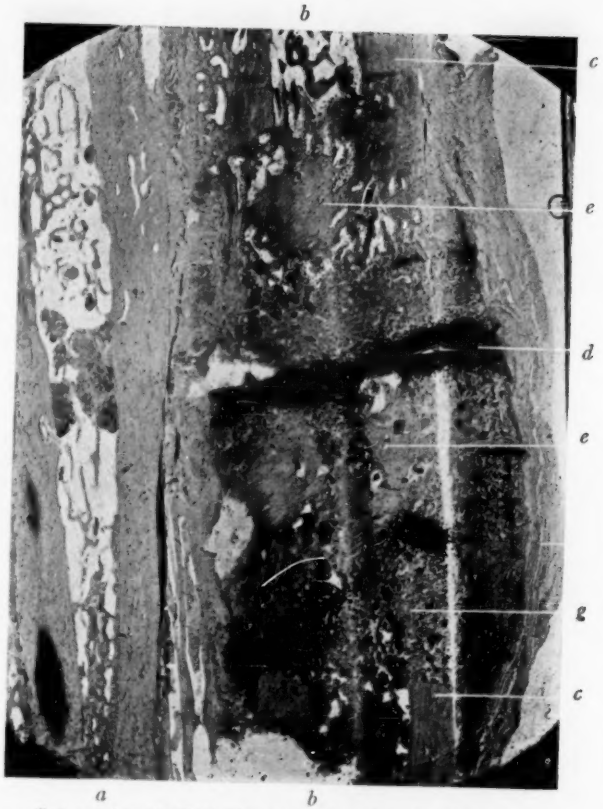

FIG. 4.—Longitudinal microscopical section of radius and ulna. Duration, 141 days. *a*, ulna; *b*, radius; *cc*, cut ends of radius with bone fragments between; *d*, cartilage forming false joint; *e*, bone fragment—nuclei do not stain—areas of rarefaction seen near periphery; *f*, fibrous tissue capsule continuous with periosteum; *g*, new bone formation about periphery of fragments.

FIG. 5.—Longitudinal section. Duration, 347 days. *a*, ulna; *b*, radius; *cc*, boundaries of transplanted fragments. Medullary cavity is being reformed. Tendency of Haversian canals to run in long axis of shaft.

FIG. 6.—Duration, 370 days. Good union; fragments have disappeared. *aa*, area of transplants.

FIG. 7.—High power of portion of transplanted fragment. *a*, fragment—nuclei of bone cells do not stain; *b*, new bone formation about the periphery of the fragment—nuclei show normal stains; *c*, blood-vessels in Haversian canals—blood-cells show normal staining reaction—two or three layers of normal appearing bone-cells about blood-vessels.

FIG. 8.—High power, showing junction of connective tissue and bone. Collagen fibres seen extending into the bone. Cells are of same character in bone and connective tissue, but the chemistry of the intercellular substance has changed. *a*, connective tissue; *b*, bone.

FIG. 9.—High power view of new bone formation. Duration, 12 days. *a*, granulation tissue; *b*, blood-vessels; *c*, new bone—the gradations of the intercellular substance can be plainly seen; there is no specific bone-cell, but a gradation of connective-tissue cell with calcium deposited as bone about it.

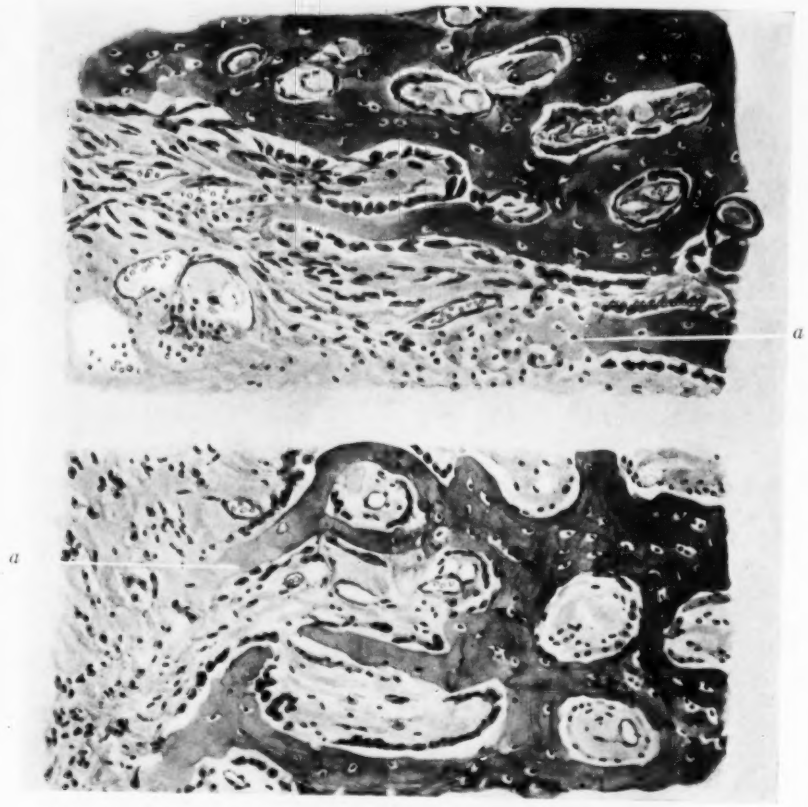

FIG. 10.—High power of bone of involucrum in case of osteomyelitis. Duration, 2 months. At *a* may be seen the gradual fading off of the bone matrix into the collagen fibres. The gradual transformation of a fibroblast to a bone-cell is seen. (Courtesy of Dr. William Clarke.)

FIG. 11.—High power of fracture of humerus. Duration, 11 days. Transformation of connective tissue into cartilage. (Courtesy of Dr. Allen O. Whipple.)

FIG. 12.—X-ray shows bone fragments filling defect. Duration, 13 days.

FIG. 13.—X-ray shows bone hypertrophy with union of fragments. Duration, 141 days.

FIG. 14.—Duration, 134 days. Fragments have united—no cross union between radius and ulna.

FIG. 15.—Duration, 370 days. Contour of bone is approaching the normal; individual fragments no longer detected by X-ray.

tive tissue forming new bone. The connective tissue cell then, by a process of metaplasia, becomes a bone cell. Periosteum is a connective tissue and hence is prone to form bone, but it is not the only connective tissue that has this function. If this theory is assumed, it will explain the extra-skeleton formation of bone as in arteries, myositis ossificans, ovaries, kidneys, etc. (Figs. 9, 10, and 11).

Neuhof, working in the experimental Research Laboratory of Columbia, found bone constantly present in fascia lata and fat transplants in the bladder and occasionally in the stomach.

In the operative treatment of comminuted depressed fractures of the skull surgeons have been accustomed to leave the fragments in place, the fragments unite and prevent the brain hernias that occurred before this procedure was adopted. Finney, at Johns Hopkins, has used this method in ununited fractures of long bones.

In the experiments described above the periosteum was removed from the fragments in order to observe if such fragments would live; clinically it would seem advisable to leave the periosteum attached, as it is plausible to assume that the blood supply will be more quickly supplied to the fragments through the medium of the periosteum.

From the clinical point of view this procedure offers an adequate method of bridging a bone defect if there is another bone present to act as a splint and if it is possible to hold the bones in adequate position by external support. It offers the advantage of not having to expose a very large area and of not having to introduce a foreign body.

No originality is claimed for this method, as bone fragments have often been used to fill bone cavities. McEwen, in his work, reports bone growth from bone fragments.

I wish to express my thanks to Dr. William C. Clarke, of Columbia University, for invaluable advice and for the privilege of performing these experiments in the Surgical Research Laboratory of Columbia University.

NOTE ON ISOLATED ABSCESSES OF LONG BONES

By A. Merrill Miller, M.D.
of Danville, Ill.
surgeon to lake view hospital

The incidence of isolated bone abscess as a part of osteomyelitis has received scant attention, and has been followed by few reported cases. Any discussion, then, concerning diagnosis may fix the attention more firmly in the minds of physicians when obscure bone lesions are being considered.

I wish to review, briefly, its symptoms, and call attention to the ease in diagnosis when present and certainty of its cure. Probably like many other simple but rare processes, it escapes detection because we do not think of it in differential diagnosis.

The history is indeed suggestive—it is always a chronic thing—the Röntgen plate is practically always diagnostic, and its cure both rapid and certain when treated by standard surgical principles governing bone lesions.

The type I have especially in mind is the closed form in which a tell-tale sinus does not communicate with the skin to give proof of deeper bone destruction. The deeply seated pain, its continuance, and, above all, muscle spasm involving the region of a joint make the diagnosis of rheumatism a very likely one. The occurrence of increased pain associated with barometric changes may seem to justify such a conclusion. Therapy calculated to relieve the angina of rheumatism is entirely without benefit; indeed, opiates are highly unsatisfactory. Nocturnal pain was a marked characteristic of the reported case.

> Mrs. S., aged twenty-eight years, foreign born, had an infection in right os calcis when a child. The wound discharged four months, when a small piece of bone came away. It then promptly closed. In about two months some soreness was noticed near the point of right deltoid attachment. This soon quieted. For the past five years she has had soreness and discomfort in the right arm; this coming on fifteen years later than the primary trouble. Symptoms have increased in severity, especially marked in stormy weather and at night. Muscle spasm fixed the arm at about 15° in the extended position. During the period of observation she never carried more than one degree of fever.

The likelihood of error is reduced to practically nothing if the suspected bone or joint is subjected to an X-ray examination and the plate properly interpreted. In brief, the findings are characterized by a dense eburnated area surrounding a translucent spot—the abscess cavity. In the long standing cases, and this is definitely a chronic process, this dense bony infiltration shows nature's response to local stimulation, the medullary cavity having disappeared as such. This fusiform bony tumor differs entirely from other lesions which might be confounded with it; *e.g.*, the absence of bony deposit

FIG. 1.—Fusiform tumor. No medullary cavity. Light area is abscess.

FIG. 2.—Showing opening in bone three days after operation.

FIG. 3.—Seven months after operation. Operative defect almost repaired. Evidence of a medullary canal.

on the convexity, as in syphilis, or the thickening on its concavity, as in rickets.

That the process is essentially one of destructive osteomyelitis is proved by the similar and constant bacterial findings in those cases where cultures have been made. It is a staphylococcus lesion, and unless secondary to a local injury, hæmatogenous in origin. The report of Dr. E. G. C. Williams of Lake View Diagnostic Laboratory was staphylococcus albus.

That its cure is surgical, and in no way affected by other than surgical measures, seems proved by rapid healing and absence of pre-operative symptoms following drainage. The principal complaint—pain—is likely due to tension within the closed bony cavity. A drill opening releases the pus with a spurt. It continues to flow till pressure has been equalized. In a typical abscess occupying the shaft, surrounded by eburnated bone, no sequestrum is present. A medullary abscess extending along the interior is quite another process and may be associated with a sequestrum.

In all reported cases the rational surgical procedure—drainage—seems to give perfectly satisfactory results. The primary drill hole must be enlarged to the periphery of the cavity, leaving a cup-like depression in the bone. Curettement shows little if any pyogenic membrane, the abscess wall being sharply defined. Simple gauze drainage of the soft parts is sufficient, an organized clot filling the bone cavity.

NITROUS OXIDE, OXYGEN, ANÆSTHOL SEQUENCE IN ORAL SURGERY

By Charles H. Sanford, M.D.

of New York

attending anæsthetist to the german hospital

It has occurred to me for the past few years that the oral operator has not always received the best kind of an anæsthesia for his patient, nor has due consideration been given the method of anæsthesia administered to patients about to have their tonsils and adenoids removed. Whether it is because this operation is so common and the patients usually uncomplaining and unsuspecting children, I do not know, but it is my belief that the patient requiring this operation is entitled to as much consideration on the part of the anæsthetist as is given the patient undergoing any major operation.

To saturate a child or older patient so deeply with ether that he remains under the influence of it long after the completion of the operation is to my mind unnecessary and harmful and therefore bad practice. This method, with its resultant gagging and strangulation, is quite faulty, it is against the well established rule of administering just enough anæsthetic as the case in hand requires, and is unscientific in this age when we are endeavoring to measure accurately the quantities and proportions of our anæsthetic mixtures and sequences. Furthermore, it has a tendency to hurry and disconcert the operator, and is responsible, I dare say, for many an uvula that has come out and part of many a tonsil that has remained behind.

It has, therefore, been my endeavor to administer an anæsthetic which was least depressing to the patient, which could be nicely controlled, and which permitted of uninterrupted and careful work in the oral cavity especially, and about the head generally. I am free to admit that this form of anæsthesia was made possible by the perfection during the past few years of many new apparatuses and devices for the administration of warmed gases and vapors which are far less irritating to the mucous membranes than the cold, unvolatilized anæsthetics. This fact should not be disregarded, for, with better equipment at our disposal, better and smoother anæsthesias should be our aim.

For work in and about the mouth, the nasal passages are convenient channels through which to pass the vapors and gases, while the pharynx, through means of endopharyngeal tubes, serves admirably for work on the nose and upper part of the head. The nasal passages, however, are quite sensitive and will not permit of the passage of strong ether vapor in quantities which are necessary, even in children, when the mouth is wide open, since this permits of great dilution of the vapor in the pharynx. With quantities of ether sufficient to keep the patient under by this means, salivation and strangulation occur as in the open administration, even to a con-

FIG. 1.—Photograph showing two bottles, heater, two-way valve attachment with surgical inhaler and special self-retaining nasal tip. Anæsthol in small bottle, ether in large one.

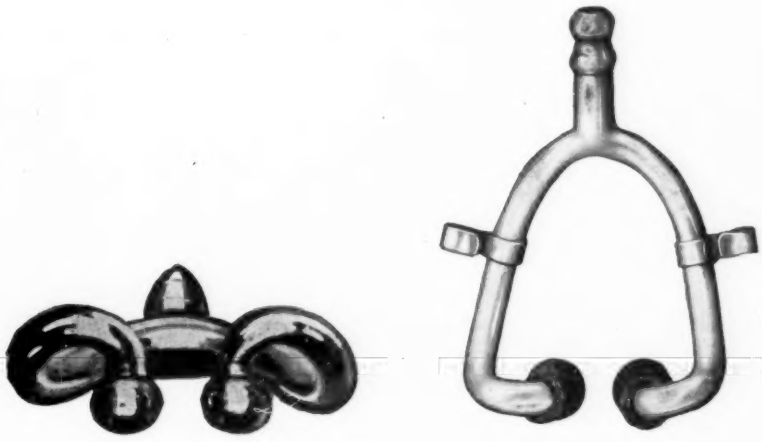

FIG. 2.

siderable degree when the vapor is warmed. Chloroform I have found unsatisfactory for use in children during tonsil and adenoid extraction, because great distress follows the temporary shutting off of respiration when the tongue is depressed.

Anæsthol, which is a mixture holding in stable chemical union 17 per cent. of ethyl chloride, 35.89 per cent. of chloroform and 47.10 per cent. of ether, seemed better suited. On account of the ethyl chloride it is quite rapid in its action, and its ether content is sufficient in stimulating qualities to offset the depressing effect of the chloroform in it.

Apparatus.—The apparatus which I have used is the latest type Gwathmey, with water sight feed, so that the proportions of gases and vapors used will be in terms of the gases bubbling through a number of holes. It is fitted with two bottles, one containing ether, the other anæsthol. At the end of the electric heater I have placed a by-pass for convenience in switching from the surgical inhaler and nitrous oxide, oxygen, ether to the nasal tip and nitrous oxide, oxygen and anæsthol (Fig. 1).

Technic.—The induction of anæsthesia has varied somewhat with the case and the individual, selecting the anæsthetic for induction according to physical conditions, temperament, age and sex. Accordingly, I have used anæsthol on a mask, then switched to the nasal tip and nitrous oxide, oxygen and anæsthol for the remainder of the operation as I shall describe later. When I use the surgical inhaler I induce with nitrous oxide, oxygen and ether as follows: The patient is rendered unconscious by nitrous oxide and oxygen alone until the characteristic stertorous breathing sets in. Then a very short jet of ether vapor is sprayed into the mixture by turning on the ether valve for a second only. This is repeated at short intervals until the patient receives the constant flow of the ether vapor without exciting a cough. When the respiration has become free and quiet, I switch over to a special nasal tip which I have recently devised (Fig. 2) and insert it into the nares, having first adjusted it before starting anæsthesia.

I now regulate the flow of oxygen and nitrous oxide to two holes in each sight feed, about 33 per cent. of oxygen and 66 per cent. of nitrous oxide, and begin the constant flow of the anæsthol vapor by very slightly turning on the valve on top of the anæsthol chamber. In a few moments you will know whether your patient is coming out or going under more deeply and regulate the flow of the gases through the anæsthol accordingly. I have seldom found it necessary to whip the anæsthol into a foam for more than a few seconds while finding or changing the plane of anæsthesia, but have kept it going in distinct bubbles.

At this rate, most patients will be carried through the operation. But I have found it convenient when desiring a deeper plane of anæsthesia to add not more anæsthol vapor per se, but more nitrous oxide, which then automatically increases the vapor proportionately. In this manner I have recently conducted an entire anæsthesia for resection of the lower jaw lasting two and one-half hours, with only an occasional slight turn of the nitrous oxide

valve. In the manner just described I have given numerous anæsthesias for dental work lasting over an hour, without interrupting the operation, without causing salivation, and with very rapid return of consciousness after stopping the anæsthesia. In some cases I was able to induce with the nasal tip, in which cases it was necessary merely to cup the hand over the mouth, induction taking about seven minutes. There is no direct advantage in this, however, it simply shows that this sequence—nitrous oxide, oxygen and anæsthol—is practically non-irritating. In children over seven years of age, I have almost regularly used this sequence after inducing with the surgical inhaler and ether, or using anæsthol on the open mask, and then switching to the nasal tip and anæsthol when the mouth gag is inserted.

The quantity of anæsthol used varies considerably with the nature of the operation, its duration and the age and sex of the patient. In the jaw resection mentioned above I used one ounce per hour during the two and one-half hours of anæsthesia, the patient, a rather slender and frail woman of fifty, fully recovering consciousness in three-quarters of an hour. For the removal of seven impacted molars, an operation lasting one and one-quarter hours, I used twenty cubic centimetres. For tonsil and adenoid cases I rarely use over fifteen cubic centimetres. The average mastoid case requires between twenty and twenty-five cubic centimetres. It will be seen from these few examples that the amount of anæsthol used is comparatively small as compared with the open method, and the advantages in regard to comfort for the operator, effect upon the patient, ease of administration, and rapid recovery without, in many instances, any nausea or vomiting, would seem to me enough in its favor to warrant its use. There has not been a single instance where I felt at all uneasy during its administration; there have been no untoward symptoms.

RECTUS MUSCLE TRANSPOSITION IN CERTAIN CASES OF INGUINAL HERNIA*

By Winfield Scott Schley, M.D.

of New York

Associate Surgeon, St. Luke's Hospital

Since the declaration of war and the operation of the draft and troop mobilization, larger numbers than usual of hernia cases have appeared. Those from whom strenuous work will be expected and who need the greatest security we can give them for their own sake and that of the nation. For this reason I have been prompted to bring the subject before you again and for discussion. While the percentage of hernial recurrence is small in those going back to ordinary avocations, we have occasionally to deal, as at present, with many going to avocations of extraordinary *physical* requirement.

In, I think, the common experience, the recurrences which take place are usually of the direct variety, through the inner half of the posterior wall of the inguinal canal. The very simple procedure of rectus transposition followed by the usual internal oblique suture of Bassini superimposed doubly insures this area where muscle is thinnest and often deficient and transversalis fascia frequently stretched and attenuated as well. It is far from every case that needs any embellishment of the classic operation, and rectus transposition in no way takes the place of Bassini's procedure, but is to be done in conjunction with it in that smaller number of cases who present well marked muscular and aponeurotic deficiencies of the inner half of the covering of Hesselbach's triangle.

From time to time patients present themselves with the inguinal variety of hernia and where the internal oblique muscle is so deficient and transversalis fascia so thin that when the external oblique aponeurosis is divided three or four fingers can be pushed into the abdomen invaginating properitoneal tissue. Many cases with good sized herniæ and weak posterior wall gave nevertheless good muscle for repair without additions. It is those who have not that we are concerned with, about six to eight per cent.

In 1913[1] I traced the history from 1890, the year of Bassini's original communication, of the attempt by various operators to fortify this area. The earlier methods were complicated and gave about five per cent. of recurrences; those of the last ten years much simpler. The suture of an atrophic

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* Read before the New York Surgical Society, January 23, 1918.

[1] Annals of Surgery, October, 1913.

internal oblique *together with* the inner half of the external oblique aponeurosis to Poupart's ligament seems to have much to commend it in simplicity, but living muscle has always proven a more permanent barrier against hernia protrusion. The procedure which seems more adequate yet hardly adds ten minutes to the operation, rectus transposition, I have followed for the last six years in nearly sixty cases where it has seemed necessary.

Retraction upward of the oblique muscle and aponeurosis exposes the rectus covering. Incising this for three and one-half inches behind the oblique aponeurosis and down to the pubes allows the rectus to be brought out without tension after the finger frees the muscle from its light attachment to

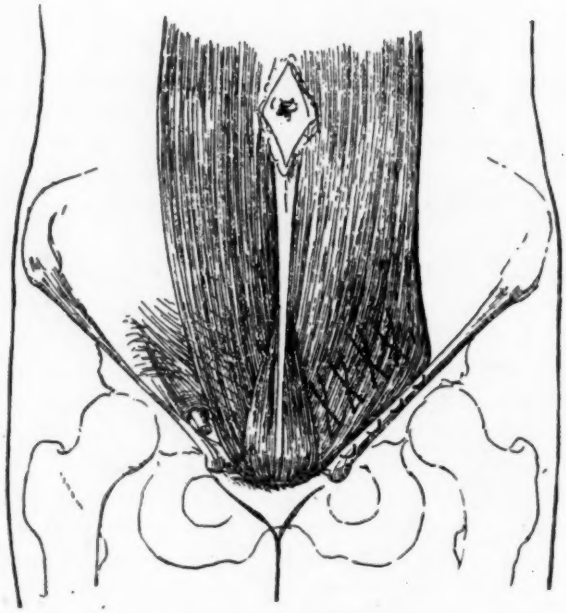

FIG. 5.—Deviation of fibres of rectus (after Bloodgood).

the sheath. Four kangaroo sutures of medium size attach it to the lowermost shelving portion of Poupart's ligament. The cord is transplanted as usual and the internal oblique and its aponeurosis sutured down over the rectus following the routine method. The external oblique aponeurosis is closed edge to edge or overlapped, depending upon its normal tension or redundancy. I would like to emphasize *the freer opening of the rectus sheath down to the pubes together with the separation of the muscle from its light attachments to the sheath* as a very great aid and sometimes necessity for the apposition to Poupart's without tension. The deviation of the muscular fibres is but little in this way and four sutures distribute what tension there may be. The lowermost stitch should leave no opening between the rectus and Poupart's liga-

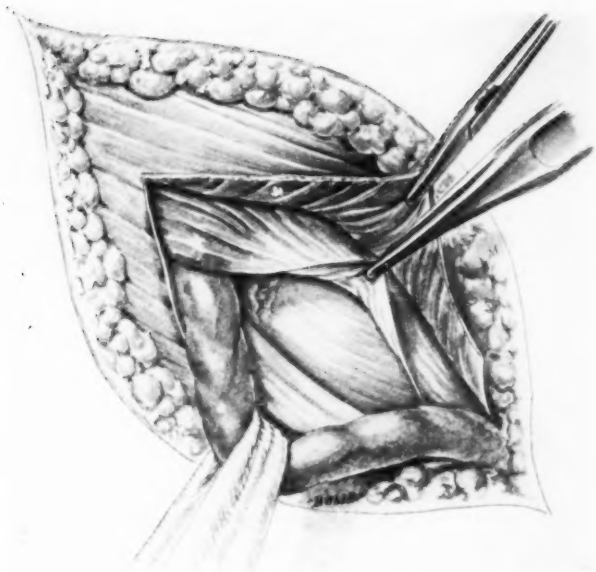

FIG. 1.—External oblique aponeurosis divided. Internal oblique muscle and aponeurosis retracted.

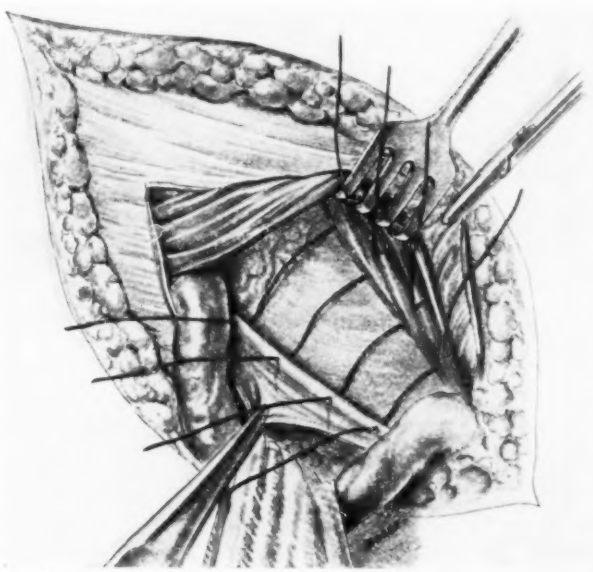

FIG. 2.—Rectus sheath opened, and, muscle having been freed, sutures are taken through muscle.

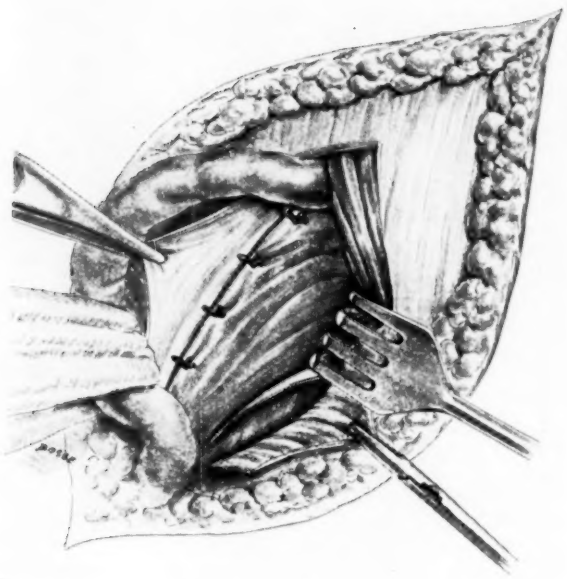

FIG. 3.—Rectus drawn to Poupart's (lower stitch should be taken nearer pubes, leaving no opening whatever).

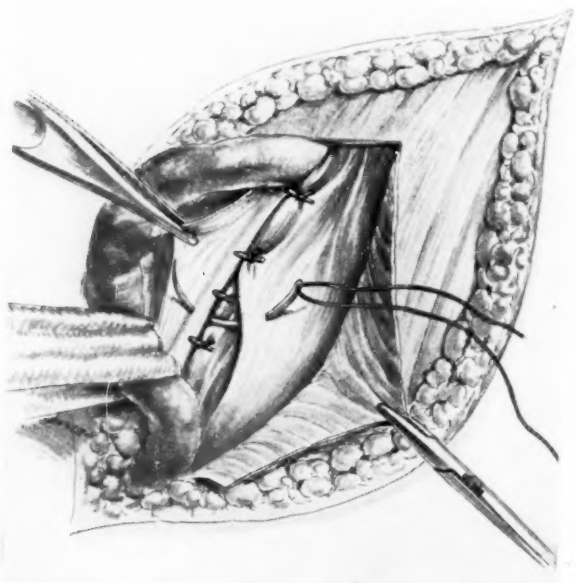

FIG. 4.—Internal oblique muscle and aponeurosis sutured well down to Poupart's over the rectus.

ment. Post-operative it is of advantage to allow these patients two pillows under the head and shoulders and one under the knees whenever they lie on the back for the first few days. Adequate rest in bed for sixteen to eighteen days will, I feel sure, get them back to duty with safety a month sooner than a week less in bed, and diminish their convalescent and disability time by so much. The function of sutures should be to bring tissues into apposition for union without strangulation and not to take any mechanical strain which the tissues themselves are capable of doing when firmly united by first intention.

It has not been possible to follow all the cases done in this way, not over one-third, but I know of no recurrences in over six years' experience with it. The procedure utilizing the rectus muscle in hernial repair has a definite indication and field of usefulness in a certain number of cases when the operation is made to fit the condition and not the condition a typical operation, however good that may be.

ON THE USE OF OLIVE OIL IN BLOOD-VESSEL SUTURING

By J. Shelton Horsley, M.D.
of Richmond, Va.

While the field for blood-vessel surgery is not a wide one, it has a distinct range of usefulness. Its use is often hindered either by unjustifiably enthusiastic and exaggerated claims of what can be accomplished, or by those who think it of no benefit in any condition. Between these extremes there is a logical middle ground. In some way an impression has gone forth that blood-vessel suturing can be done only by a few surgeons of peculiar skill and should not be employed by the average "practical" surgeon. A method that is so confined ceases to be of much real value, and any step that tends to simplify blood-vessel suturing and make it more popular is a distinct advance in the progress of general surgery.

The advantages of a technic in which a broad surface of vascular endothelium can be approximated and held by a double mattress suture, and in which all sutures can be applied under the same tension, have been pointed out in previous communications. (Annals of Surgery, 1912, vol. lv, pp. 208–214; *Journal of the American Medical Association*, 1912, vol. lix, pp. 4–8; *Surg., Gyn. and Obst.*, 1914, vol. xviii, pp. 536–545; and "Surgery of the Blood-vessels," by J. S. Horsley, C. V. Mosby Co., pp. 46–77.) But even with this technic which appears to overcome many objections, there is a rather constant percentage of cases in which the lumen of the vessel becomes obliterated after suturing. With more skill and experience in experimental work, this percentage of failures can be definitely diminished to about 15 or 20 per cent. in the hands of the average operator. Occlusion means technical failure. If the occlusion is sudden the vessel might as well have been ligated. If it is slow, collateral circulation may form and the function be as satisfactory as though the vessel remained permanently patent.

While this work is somewhat more delicate than the suturing of intestines, there is no reason why any competent surgeon who cares to spend a little time in experimental work cannot master the technic. He who can secure nearly 100 per cent. of successful results in experimental resection of the bowel should be able to attain more than 75 per cent. of successful results in experimental blood-vessel suturing. But 15 or 20 per cent. is too high a percentage of occlusions.

It has been considered a matter of great importance to use either vaseline or some paraffin oil in blood-vessel suturing, not only to smear over the ends of the exposed vessels, but the stitches must be impregnated in this material. It has been thought that this would both prevent drying of the vascular endothelium and seal in the tissue juices from the incised vessel walls.

Dr. J. B. Blake, of Boston, has recorded some interesting experiments in

FIG. 1 FIG. 2

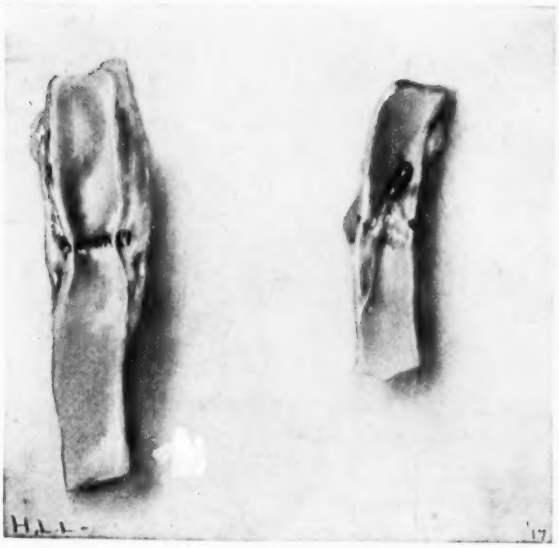

FIG. 1.—Lumen of right carotid of a dog which had been severed and reunited by sutures. Specimen removed twenty-seven days after operation. In all of these specimens, olive oil was used for the sutures and to prevent the endothelium from drying. This specimen shows a perfect lumen. The sutures which are apparent in the lumen are covered with a thin layer of transparent endothelium. The reasons why the sutures are more conspicuous a week after the suturing than at the time of suturing are explained in the articles referred to in the text.

FIG. 2.—Lumen of left common carotid of a dog which had been severed and reunited by sutures. Specimen removed twenty-seven days after operation. Olive oil was used. The lumen is obstructed but not occluded.

FIG. 3 FIG. 4

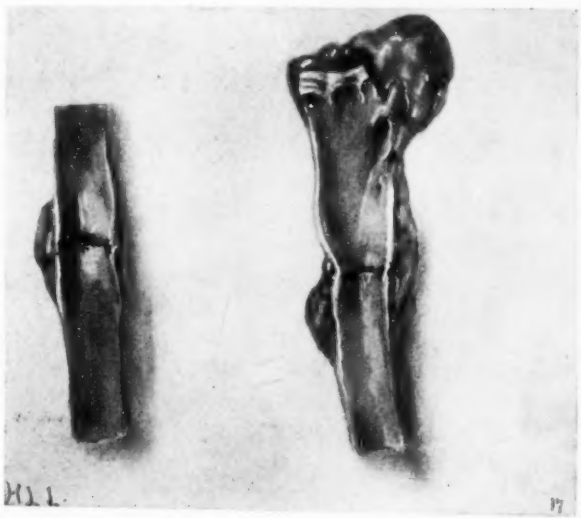

FIG. 3.—Lumen of right carotid of a dog which had been severed and reunited by sutures, using olive oil Specimen removed twenty-one days after operation. Lumen is apparently perfect.

FIG. 4.—Lumen of an arteriovenous anastomosis in which the carotid was sutured to the external jugular vein. Specimen removed twenty-one days after operation. Olive oil was used. The lumen is apparently perfect.

which he used sterile olive oil to prevent adhesions of the intestines after abdominal operations (*Surgery, Gynecology and Obstetrics,* vol. vi,, 1908, p. 667). Cubbins and Abt (*Surgery, Gynecology and Obstetrics,* May, 1916, pp. 571–579) reported experiments with various substances that are supposed to prevent adhesions. Among other things they used white and yellow vaseline, albolene and lanolin, and found they had an irritating effect upon the peritoneum. They say that "vaseline is an intense irritant to the normal peritoneum of a dog, and that it is absorbed very slowly, if at all." They mention two patients upon whom they operated, in both of whom vaseline had been used in the abdominal cavity three or four months before. They say that "the walling off of the vaseline in the belly of these two humans was just as firm as if it had been around an abscess." They found that white vaseline, albolene and lanolin were as irritating as the ordinary yellow vaseline. Paraffin oil did not prevent adhesions, though it is considered "far less irritating to the peritoneum than vaseline." Olive oil, however, according to their experiments, is non-irritating and is slowly absorbed, though it prevents adhesions only in about 20 per cent. of the cases.

A substance that has an irritating effect upon the peritoneal endothelium would probably have a similar effect upon the vascular endothelium. Then, there is a possibility of absorption and oxidation of olive oil that does not occur with vaseline or paraffin oil. Bearing these facts in mind, and particularly the well proven non-irritating effect of olive oil on the peritoneal endothelium as shown by the experiments quoted, I tried olive oil instead of vaseline or paraffin oil in a few experiments in blood-vessel suturing. There were 4 experiments on two dogs. In 3 of these the carotid artery was severed and reunited, and in one, after tying the distal end, the cardiac end was sutured to the distal end of the severed external jugular vein. The technic employed is described elsewhere (*Surgery, Gynecology and Obstetrics,* 1914, vol. xviii, pp. 536–545, and "Surgery of the Blood-vessels," by J. S. Horsley, C. V. Mosby Co., pp. 46–77).

Dog No. 1, in which both carotids were severed and then sutured together, was killed under ether twenty-seven days after the operation. The right carotid, which was sutured first, showed a perfect lumen (Fig. 1). In the left carotid there was a partial occlusion, though it was not complete (Fig. 2). The endothelium is smooth on both sides of the sutures, but apparently a small clot had formed at one point on the suture line and became organized. At the tip of this small organized clot a more recent red clot had formed. This specimen was the second operation on that dog, both being done under the same anæsthetic and with the same instruments, and it is possible that some slight infection may have occurred at this point. In the other two experiments in Dog No. 2, the carotid artery was severed and reunited on one side and the cardiac end of the carotid was sutured to the distal end of the external jugular vein on the other. Both specimens (Figs. 3 and 4) showed perfect lumens when the dog was killed twenty-one days after operation. It is sometimes difficult to secure a perfect lumen in suturing an artery to a vein, but the result in this instance was entirely satisfactory.

Judging from these few experiments I believe that the use of olive oil in blood-vessel suturing will probably be attended by a larger number of successes than will the use of vaseline or paraffin oils.

The chief objection to the use of olive oil in the technic employed is that when the threads are wrapped around the buttons on the suture staff they do not hold as satisfactorily when they have been boiled in olive oil as when they have been boiled in vaseline. This can be readily overcome by smearing some sterile vaseline on the buttons of the suture staff just before the sutures are wrapped around them, and there need be no occasion for the vaseline to come in contact with the vascular endothelium.

NOTE ON SAPHENOUS VARIX SIMULATING A FEMORAL HERNIA

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The following case illustrates a condition which appears to enjoy the distinction of having usually led the modern clinical surgeon into diagnostic error. At least the reported cases, with few exceptions, are confessions of mistaken identity. This one was an arch-offender, having misled and humiliated in succession at least five learned and distinguished surgeons.

Mrs. R. M., white, aged thirty-eight years, was admitted to the gynæcological department of the Johns Hopkins Hospital on March 4, 1917, complaining of certain symptoms referable to her pelvic organs and of a swelling in the right groin. She had previously undergone two major operations; one four years ago for radical cure of a right femoral hernia and appendectomy, and one in January of this year for a right oblique inguinal hernia. Unfortunately, however, after both operations, when she had convalesced sufficiently to get out of bed, the pesky lump promptly reappeared in the right groin. I first saw her on March 7, 1917, a few weeks following her discharge from the hospital after the second operation. The examination disclosed a swelling the size of a hen's egg directly over the femoral canal, which promptly and completely disappeared in the recumbent posture. A definite impulse and bulging were demonstrable when the patient coughed, but I was unable to recognize either a patent femoral canal or any palpable contents of a hernia sac. The situation of the swelling was particularly interesting in its relationship to the two operative scars, one of which was above Poupart's ligament and the other at least five centimetres below and parallel to it, while the lump appeared midway between them. I made my incision directly over the tumor, but instead of directly exposing a hernia sac, I encountered in the subcutaneous tissues of the groin just over the cribriform fascia and the femoral canal a small circumscribed mass of fatty tissue containing a few lymphatic glands and a plexus of much dilated veins. Both the external abdominal ring and the femoral canal were tightly closed and there were no signs of a hernia present. By withholding the anæsthetic and permitting the patient to retch, we were able to positively exclude the existence of a hernia and to observe an enormous distention of the mass of veins. At its lower margin the internal saphenous vein was easily identified and it became obvious that we were dealing with a circumscribed varix of the upper portion of this vein together with its adjacent tributaries. The ligation and division of the trunk veins with excision of the mass of varices and fatty tissue was technically simple. It was interesting to note that there were no varicose veins lower down in the leg. At the time of her discharge from the hospital the patient was apparently cured.

A survey of the literature shows that circumscribed saphenous varix in the region of the femoral canal and external abdominal ring, while uncommon, nevertheless has long been recognized by surgeons as a condition to be differentiated from both inguinal and femoral herniæ. I have collected reports of 10 cases, the earliest being by a French observer, Boinet, in 1836. Seven of these were diagnosed prior to operation either as incarcerated or strangulated femoral hernia.

The condition closely resembles a femoral hernia not only in the size, shape and location of the tumor mass, but also in that it disappears on lying down and imparts a distinct impulse on coughing. The differential points are, first, its unusual softness; second, a perceptible thrill which is imparted to the palpating finger when the patient coughs or if slight pressure be made over the mass while the blood escapes from the dilated veins when the patient first lies down; third, having reduced the tumor, if sufficient pressure is made over the femoral canal to prevent the escape of bowel or omentum, and the patient then be allowed to stand up, the tumor will be seen gradually to reform; and, finally, the association of varicose veins lower down in the leg is frequent and is a helpful point in diagnosis.

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THE RECURRENCE OF SYMPTOMS FOLLOWING OPERATIONS ON THE BILIARY TRACT*

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The prolonged and detailed discussion regarding the advisability of drainage or of removal of the gall-bladder has been valuable and convincing in that it has created a better understanding of the treatment of gall-bladder conditions. Most of us are convinced that in the majority of cases the results will be more satisfactory if the gall-bladder is removed, though I think we are also convinced that the organ has definite functions and should not be deliberately sacrificed unless there is sufficient evidence to show that it is a source of infection.

The function of the gall-bladder is not definitely known, though probably definite compensatory changes do take place when it is removed. We have reported the results of our studies of the changes that take place when the gall-bladder is removed from animals.[3, 4] There was no dilatation of any part of the duct if the sphincter at the ampulla was destroyed at the same time that the gall-bladder was removed. Removal of the gall-bladder in dogs, and this probably holds true for all animals and species of animals having a functionating sphincter of Oddi, produces a uniform dilatation of all the extrahepatic biliary ducts. Investigators of the subject agree that this dilatation takes place very quickly after the cholecystectomy and soon reaches its maximum development.

The process producing the dilatation probably is as follows: The liver secretes bile almost continuously, although the rate of secretion varies. The maximum intraduct pressure at which the liver can secrete is relatively low, and probably never exceeds 300 mm. of water. The escape of bile into the duodenum is at least partially under the control of the sphincter of Oddi. This sphincter when below normal in tone may be able always to withstand the pressure of 100 mm. of water and when thrown into spasm it can resist a much greater pressure, probably as high as 600 mm. of water. It is also evident that, owing to the course of the common duct through the duodenal wall, passing waves of peristalsis will momentarily prevent the escape of bile into the intestine. This fluctuation of intraduct pressure produced by the variation of the rate of bile secretion and bile escape into the intestine is, in all probability, compensated by the gall-bladder. After the removal of the gall-bladder, this mechanical action producing change in the intraduct pressure still persists, but, owing to the decrease in the total capacity of the biliary tract, the maximum pressure produced is much higher; consequently, that portion of the biliary tract most susceptible to dilatation, that is, the extrahepatic ducts, dilates. The amount of dilatation will depend on (1)

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the resistance to the escape of the bile, (2) the relative capacity of the biliary tract, and (3) the resistance of the duct walls or periduct structures. The secretory pressure of the liver, although varying greatly, will always be enough to produce some dilatation of the ducts, if enough resistance is offered to the escape of bile. In cases in which the resistance to the escape of bile is low, as occurs normally in some persons because of the lack of function of the sphincter, or, experimentally, when all the muscle fibres surrounding the duct at its entrance into the duodenum have been destroyed, little or no dilatation will occur. Also, the duct will not dilate in those cases in which the capacity of the biliary tract is such that it can accommodate itself to the changes due to variation between the rate of secretion and the rate of escape. The pressure producing the dilatation is relatively quite low, probably seldom greater than 100 mm. of water, consequently, if the duct walls are resistant, or if other structures, such as the pancreas or adhesions, press on them, dilatation will not occur. In the dog, the weakest portion of the wall of the duct is at the juncture of the upper hepatic ducts. This region always shows the greatest dilatation after the removal of the gall-bladder. These results may be controlled by ligation of the common bile-duct. In a very few hours after ligation, this particular part of the biliary tract will be dilated. Whether or not the cystic duct dilates after the removal of the gall-bladder depends on these same factors. It will not dilate (1) if the resistance to the escape of bile is below the resistance of its own walls to dilatation, (2) if the capacity of the biliary tract is so great that sufficient variation in pressure does not occur to overcome this resistance, (3) if adhesions have formed around it, or (4) if other less resistant portions of the biliary tract dilate to accommodate the variation of pressure. Such dilatation has often been observed during operations on man and is especially noticeable in hydrops of the gall-bladder, in which instance the gall-bladder has been without function for some time and this compensatory change has taken place. It has also been observed in persons from whom the gall-bladder had previously been removed.

Apparently there are no untoward results from the removal of the gall-bladder. I have been able to obtain reports from fifteen persons who have been without their gall-bladders for fifteen or more years, and, so far as I can determine, they are not inconvenienced and are living normal lives. In following up these cases, it was interesting to note that one of the frequent symptoms of cholecystitis, the frequent belching of gas, persisted in several of the cases, in spite of the fact that the patients had been without their gall-bladders for so long a time. Persons who have had their gall-bladders removed also often note the passage of large quantities of bile from their bowels. They state that this may come between the normal passages; it usually occurs within the first year and may then disappear. Most persons are not disturbed by the removal of the gall-bladder. Knowing this we certainly should feel justified in removing the organ in most instances in which we believe that the immediate and ultimate results will be satisfactory.

Some investigators are inclined to believe that cholecystitis without stones and cholecystitis with stones are two entirely distinct conditions, and that cholecystitis exists continuously without the formation of gall-stones. This would certainly point to a definite indication for the removal of the gall-bladder.

Recurrences are much more common following drainage of the gall-bladder and a definite number of such cases will require secondary operation, and while recurrences are much less frequent after its removal, there are not uncommon instances in which there was infection or stones in the ducts. Deaver reports that in 4.07 per cent. of the cases in which he operated at one hospital the operations were secondary. He says that the most common cause of recurring trouble after drainage was stones in the gall-bladder, and next in frequency were adhesions and stones in the common duct. Most of his patients required re-operation within a year. He had only re-operated in 4 cases following the removal of the gall-bladder; in 2 for stricture of the pancreatic part of the common duct; in one for stone in the common duct, and in one for duodenal fistula. He further states that removal of the gall-bladder reduces the risk of future trouble. Eisendrath has reported 11 cases of recurrence from various causes.

According to these observers and from a review of our own cases, we believe that recurrences of symptoms in biliary cases are most often due to (1) the recurrence or persistence of infection, (2) reformed or overlooked calculi, and (3) chronic pancreatitis. Faulty technic in suturing the fundus of the gall-bladder to the abdominal wall seemed to be responsible for the symptoms in a number of cases of recurrence. To adhesions have been attributed the recurrence of symptoms and undoubtedly they are a factor, though in the majority of our cases in which the adhesions were most dense there seemed to be some inflammatory trouble as an etiologic factor which produced the adhesions as well as the recurring symptoms. In some of the cases in which secondary operation was necessary the adhesions were very numerous and firm.

Dr. S. W. Harrington and I have recently reviewed the histories of patients operated on for recurrence in the past two years at the Mayo Clinic. There were 2027 operations, of which 219 (10.8 per cent.) were secondary. A large number (80 per cent.) of the operations were for the removal of the gall-bladder, a procedure which has been accepted in the clinic as the operation of choice. The drainage operation has a much higher mortality, but this is not attributed to the operation itself, since it was usually performed in cases in which the least possible operating was done because of the precarious condition of the patient, or because it was almost technically impossible to remove the gall-bladder at the time. It is our custom in badly infected cases, and in patients who are poor risks, to drain the gall-bladder at the first operation with the idea that it may possibly have to be removed at a later date when the patient is in better condition. However, if conditions are reasonably favorable, it seems advisable to remove all infected gall-bladders

at the first operation. At the present time, with a larger experience in these cases, we are removing gall-bladders which previously we believed should be drained.

One hundred and twenty of the 219 secondary operations were for the removal of gall-bladders which had been drained previously. There was only 0.8 per cent. mortality in the series, showing that the risk in the secondary operation is no greater than in the primary operation. In 4 of the 219 cases, a secondary cholecystostomy was done because the general condition of the patient contra-indicated any further procedure. Two of these patients died. In 109 of the 219 operations, calculi were found either in the gall-bladder, the ducts, or in both. One hundred and fifty-three patients had cholecystitis, in some instances associated with stones. Adhesions were especially noted in 148 cases, and in 41 there was a definite pancreatitis. Either a mucous or a biliary fistula was present in 37 cases. Seventeen of the 209 patients were definitely jaundiced. At the time of the first operation stones were found in 154 of the 219 cases; in the gall-bladder in 140, in the ducts in 9, and in the gall-bladder and ducts in 5. Stones were found at the second operation in 109 cases; in 59 cases in the gall-bladder; in 9 in the gall-bladder and ducts; and in 41 in the ducts.

In 64 of the 219 cases both the primary and secondary operations were performed in our clinic, so that we had accurate data, but in the remaining cases we were dependent for the data regarding the first operation on the history given by the patient, which in all instances was not very complete. For this reason a more detailed study has been made of the 64 cases. From 51 of the patients in this group stones were removed at the first operation, and of these stones were removed at the second operation in 35. It would seem, therefore, that in some instances at least, all of the stones were removed at the primary operation. I removed a large stone from the common duct on three different occasions from one patient. In this case, the gall-bladder was removed at the first operation and the patient was entirely free from symptoms for more than a year, and also for about one year following the second operation. It is now almost a year since the third operation was performed and there has been no evidence of trouble. It is often impossible to be certain that small stones have not slipped back into the liver, especially if the ducts are greatly dilated. When possible, the finger should be introduced into the lumen of the duct. On several occasions we have been able to wash out multiple small stones with the suction syringe. Long continued drainage with the T-tube should be instituted in some of the cases. In a considerable number of the 35 cases in which stones were removed at the second operation, drainage only was done and no attempt made to locate stones in the ducts at the first operation because an abscess was present. For this reason these cases could be designated as those of overlooked or re-formed stones. At the first operation it seemed better to relieve the infection and then remove the stones later. Some of these cases should be classified as requiring a two-stage operation, the first for drainage

of infection, usually outside the gall-bladder (in one of our cases in the subphrenic space), and the second for the removal of the stone and drainage of the common duct.

In 37 of the series of 64 secondary operations, a drainage operation had been performed primarily; 29 for stones and 8 for cholecystitis. Of the 29 patients with stones in the gall-bladder at the first operation, 13 had stones in the gall-bladder at the second operation, and 4 of these had stones in the ducts also. It seems almost incredible that stones could have been left in the gall-bladder, and in most of these cases I believe that they had either re-formed in the infected gall-bladder or had developed from very minute calculi buried in the mucous membrane of the organ at the time of the first operation. It is also interesting to note that of the 8 cases in which drainage was done for cholecystitis, in 2 stones or stony material which was not present at the first operation was found later. In 12 of the 64 cases, the primary operation was cholecystectomy; in 6 of these stones were removed from the common duct at the second operation. Whether or not the common duct should be opened at the time of the first operation depends somewhat on the clinical history of the case. In most instances the stones can be palpated, but even if they are not felt the common duct should be opened, provided the history is suggestive, or if there is evident inflammation in the wall of the duct. I do not believe that the common duct should be probed in every gall-bladder operation, since very little can be accomplished by probing a normal sized and normal appearing common duct. If there is sufficient evidence of a common duct infection, the duct should be opened even though no stones are palpated. This can be done in the ordinary case with little additional risk. From the number of instances in which patients are re-operated for stones in the common duct, I think we must conclude that stones will sometimes re-form in the duct.

The impressions we have gained in reviewing this series of 2027 cases are that:

1. Removal of the gall-bladder reduces the risk of later troubles, and ordinarily is to be preferred to cholecystostomy for drainage.

2. It is not necessary to open and probe the common duct at every gall-bladder operation.

3. Infection in the liver, gall-bladder, or ducts is the most frequent cause of secondary trouble, and may recur many years after the primary operation.

4. The recurrence of stones is more frequent in the gall-bladder than in any other part of the biliary tract. The common duct is next in point of frequency.

5. In a definite small percentage of cases stones will be overlooked in the common duct; in other cases the stones re-form in the duct.

The following are abstracts of the histories of 5 cases in which more than one operation was done for the removal of stones from the common duct. There was much evidence of re-formation of stones and infection in

these cases. The infection apparently persisted in some cases; in others there were no symptoms of infection over a long period.

CASE I (146221).—B. R., a male, aged sixty-two years. First operation November 26, 1915. Two soft stones one-half inch in diameter were removed from the common duct, one being impacted into the ampulla. The patient was well for a year, except that he had an occasional chill. These grew more severe, and about one year after the operation he became jaundiced. In addition to the drainage of the common duct, the gall-bladder was removed at the time of the first operation. The second operation was performed January 13, 1917. At this time stones were found in the remnant of the cystic duct as well as in the common and hepatic ducts. They contained much muddy material, and there were two large stones in the ampulla of the common duct. In this case the infection and process of stone formation apparently continued in spite of the free drainage of the ducts.

CASE II (129803).—Mrs. P. K., aged sixty-five years. First operation May 14, 1915. Several stones were removed from the common duct. A fistulous tract between the cystic duct and duodenum and also a pancreatitis were noted. The common duct was drained and the gall-bladder removed. Seven months later jaundice appeared and there was other evidence of infection in the common duct. A second operation was performed May 17, 1916, and a stone was found in the hepatic duct.

CASE III (123150).—Mrs. J. D., aged forty-one years. First operation February 1, 1915. There was empyema of the gall-bladder, and many stones were found in the common duct. A cholecystectomy was done, the stones were removed from the common duct and the duct drained. The patient felt well until three weeks before she returned for examination (January, 1916), because of an attack typical of stones in the common duct. The second operation was performed February 11, 1916, when six small stones were removed from the common duct, and several small stones were brought down from the hepatic duct with a scoop. There was some evidence of infection in the ducts and in the liver, persisting after the operation. However, there were no attacks of severe pain until March, 1917, when all the evidence of common duct stone, chills, fever, and jaundice returned. The third operation was performed June, 1917. At this time many stones were found in the common and hepatic ducts; several were wedged into the ampulla. The common duct easily admitted a finger, and a finger could also be passed into the hepatic ducts. Drainage was prolonged and the duct washed out for several weeks. The patient has remained well since the third operation.

CASE IV (99023).—Mrs. W. M., aged fifty-nine years. First operation January 20, 1914. Choledochotomy and cholecystectomy were done. The gall-bladder was large, thick-walled and filled with foul-smelling, thick bile. One large and a number of small stones were found in the gall-bladder and small stones and pasty bile in the common duct, which was drained. The patient had absolutely no trouble until

August, 1916, two years and six months after the first operation. At this time there was a typical common duct syndrome. A second operation, choledochotomy with the removal of a stone and drainage, was performed October 17, 1917. The common duct was markedly dilated and contained one stone the size of a pigeon's egg.

CASE V (177791).—A. O. H., a male, aged fifty-six years. The first operation was done November 24, 1916. The gall-bladder was very large, filled with foul-smelling bile, and contained considerable flocculent material. The common duct was one-half inch in diameter and contained a soft stone together with considerable putty-like material. Following this operation the patient regained his normal health and was well for about five months, when all symptoms of the former trouble returned. A second operation was done May 11, 1917. At this time the common duct was the size of a finger and contained a soft, crumbly stone one-half inch by one inch, which was removed from the pancreatic end of the duct.

The following are abstracts of the histories of six cases in which a cholecystectomy as a primary operation and removal of stones from the common duct as a secondary operation were done. It is probable that infection existed in the common duct in these cases at the time of the first operation, that it became active later and was the cause of the formation of the secondary stones. In some of the cases stones may have been present at the time of the first operation.

CASE VI (78278).—Mrs. E. A. R., aged sixty-one years. The first operation, a partial cholecystectomy for empyema of the gall-bladder, was performed April 23, 1913. Stones were found in the gall-bladder and cystic duct. Slight attacks occurred after the operation, although the patient was comparatively well until the fall of 1916, when the attacks became severe and there was slight jaundice. A second operation was done October 27, 1916, and two stones the size of hazel-nuts were removed from the common duct. The adhesions were very marked.

CASE VII (83151).—Mrs. P., aged thirty-eight years. The patient was operated on April 25, 1913. The gall-bladder, which was removed, was very thick-walled and contained pus and one large stone. There was one stone in the cystic duct. There were no symptoms whatever for two and one-half years, then repeated attacks of typical colic occurred. A second operation revealed a dilated cystic duct which had also been present at the time of the first operation. One stone, one-half by one-fourth inch, was found in the hepatic duct.

CASE VIII (146675).—Mrs. M. H., aged sixty-five years. This patient had been operated on elsewhere eight months previously, and stones had been removed from the gall-bladder. Eleven weeks after the operation the attacks returned. December 3, 1915, a cholecystectomy was performed. The gall-bladder was large and filled with tarry bile and stony material. The common duct was dilated, and the pancreas œdematous. February 1, 1916, a choledochotomy was done and one stone was found in the common duct.

CASE IX (6385).—J. M., male, aged fifty-eight years. The first

operation, cholecystectomy, was done November 19, 1915. Many stones were found in the gall-bladder. Pancreatitis was present. Attacks came on very soon after the operation and in a short time were very severe. A second operation, choledochotomy, was done four months later and one stone, which could not be palpated, was removed from the common duct.

CASE X (156077).—Mrs. C. H., aged thirty-eight years, gave a history of typical attacks accompanied by jaundice. Cholecystectomy was performed April 11, 1916. There were a large number of stones in the gall-bladder. The patient was well for six months, when there was a recurrence of the attacks. A choledochotomy was done March 22, 1917. The common duct was greatly distended and contained one stone.

CASE XI (54104).—Mrs. L. A., aged thirty-seven years. Cholecystectomy for cholecystitis and a large number of stones in the gall-bladder was performed July 15, 1915. The patient was fairly well for one year, when there was a recurrence of attacks similar to those she had had before operation. Choledochotomy was done at the second operation. The common duct was slightly dilated but no stone found. There was a small amount of calcareous material in the bile.

The following are abstracts of 13 cases in which the gall-bladder was drained and stones were removed at the primary operation, and in which stones were found in the gall-bladder at the secondary operation:

CASE XII (191934).—H. B. K., a male, aged forty-four years, was examined April 19, 1917, two weeks after the onset of attacks. Six severe attacks of acute pain and tenderness in the gall-bladder area without fever have occurred. There had been no chills or jaundice. He had lost 10 pounds in two weeks. No morphia had been given. The first operation, cholecystostomy for acute empyema of the gall-bladder with stones, was done April 20, 1917. The patient gained rapidly in weight and strength, but he returned later because of mucous drainage from the wound. The second operation was done May 11, 1917. There was an acute cholecystitis on a chronic condition; the gall-bladder was necrotic and a single stone blocked the cystic duct.

CASE XIII (88862).—C. L., a male, aged forty-five years, was examined July 2, 1913. He gave a history of having had three severe attacks of typical gall-bladder colic in the previous two weeks. The attacks were relieved by morphine. There had been no vomiting or jaundice. The first operation, cholecystostomy, was done August 4, 1913. One large stone and bile sand were found in the gall-bladder. The patient returned for examination in March, 1917. After having been well for three and one-half years he had had an attack of pain, three attacks in the preceding three weeks, very similar to those from which he suffered before the operation. There was no jaundice. Morphine had been given for relief. Cholecystectomy was performed March 14, 1917. Cholecystitis with one stone in the gall-bladder was found.

CASE XIV (36335).—O. P., a male, aged thirty years, was examined April 12, 1910. He gave a history of having had in one year eight similar attacks of pain in the epigastrium radiating to the right side, to the back and shoulder. There had been no fever, vomiting or jaundice. Cholecystostomy was done May 10, 1910, many stones being removed from the gall-bladder. The patient returned, having had more or less constant trouble beginning about one year after the operation. There had been pain in the right hypochondrium, regurgitation and eructation of gas and food; the attacks lasted from two to three hours on from two to four days. The second operation, cholecystectomy, was done April 27, 1917. Subacute cholecystitis with one stone in the gall-bladder was found.

CASE XV (5704).—Mrs. J. E. S., aged forty-one years, was examined January 17, 1908. Her trouble began twenty-one years previously with indigestion, eructation of gas and food, and dull pain in the epigastrium. She was well between the attacks. Recently she had had attacks of epigastric pain more frequent and severe, requiring morphine. There was soreness but no jaundice. A cholecystostomy for stones in the gall-bladder was done January 27, 1908. The patient remained well for seven years and then began to have attacks of gastric disturbance with some pain along the right costal margin. She was well between attacks. A second operation, cholecystectomy for cholecystitis with stones in the gall-bladder, was done May 19, 1917.

CASE XVI (21761).—Mrs. F. J., aged twenty-five years, was examined June 3, 1909. Two months after the birth of her second child she began to have attacks of severe pain in the epigastrium, radiating to the back and to the right shoulder. Morphine was given. Cholecystostomy was done June 24, 1909. A large number of small stones were found in the gall-bladder. The patient remained well for seven and one-half years; she then had an attack of sudden, severe pain in the right upper abdomen with residual soreness and digestive disturbances. Physical examination revealed a mass in the right hypochondrium. Second operation May 30, 1917. Cholecystectomy for cholecystitis with stones. The large cystic duct contained a stone; the common duct was markedly dilated.

CASE XVII (27601).—Mrs. A. M. W., aged thirty years, was examined August 12, 1909. Since the patient was twelve years of age she had had innumerable attacks of epigastric pain, radiating to the back and accompanied by vomiting. The appendix had been removed five years previously but without relief. First operation August 18, 1909. Cholecystostomy for stones in the gall-bladder. A large single kidney was found. The patient remained well for five years. In the last three years she had had nine violent attacks (typical gall-bladder colic), requiring morphine. There had been no digestive disturbances between attacks. A second operation, cholecystectomy, was done July 12, 1917. Cholecystitis, a large gall-bladder filled with stones, and pancreatitis 1 on a scale of 4, were found.

CASE XVIII (59889).—Mrs. H. W. C., aged thirty-one years, was examined October 10, 1911. Eructation of gas and food without pain

had begun ten years previously. Such digestive disturbances continued for two years. Five years previously a sudden, severe gall-bladder colic occurred. There was no jaundice. Four similar attacks have occurred since then. Cholecystostomy was done October, 1911, for stones in the gall-bladder. The patient returned December 20, 1916. She had had no symptoms for about two years following the operation, then began having digestive disturbances, eructations of gas and food immediately after meals and pain in the region of the right shoulder. There had been no epigastric pain, no severe colics or jaundice. Second operation June 20, 1917. Cholecystectomy was done for stones in the gall-bladder. Tuberculosis of the gall-bladder and immediate vicinity was found, apparently originating near the fundus of the gall-bladder.

Case XIX (83110).—Mrs. R. C., aged fifty-seven years, was examined April 21, 1913. The patient gave a four-year history of attacks of gall-bladder colics, gradually becoming more severe and frequent, and requiring morphine for relief. There had been nausea, vomiting, and residual soreness, and gall-stones had been passed on three occasions. A cholecystostomy was done April 23, 1913. A large number of stones were found in the gall-bladder. The patient had no trouble for three years; she then began to have attacks of pain across the upper abdomen, especially on the right side, the pain gradually becoming more severe with each attack. Morphine was given for relief. The attacks lasted from one to three hours. There was no vomiting or jaundice. The second operation, cholecystectomy, was done July 25, 1917. A large number of stones were found in the gall-bladder and cystic duct.

Case XX (8302).—Mrs. F. W. K., aged twenty-eight years, was examined March 27, 1908. This patient had had typhoid fever when fourteen years of age and again when nineteen, and scarlet fever at the age of twelve. Her first attack came on in the fourth month of her second pregnancy. There was severe pain in the epigastrium, requiring morphine, but there was no vomiting, no jaundice or soreness following the attack. Since then she had had typical attacks every three or four months, each one becoming more severe and always relieved by morphine or induced vomiting. Thirty pounds loss of weight in the preceding six weeks. The first operation, cholecystostomy, was done March 29, 1908. Stones were found in the gall-bladder. The patient remained well for seven years and then, in the fifth month of her third pregnancy, she had a severe colicky pain in the right hypochondrium, radiating along the right costal margin to the right shoulder. She vomited and there was a questionable jaundice. Three similar attacks occurred before the child was born. During the intervals between attacks, her digestion was good. Second operation, cholecystectomy, February 3, 1916. A large number of small stones were found in a strawberry gall-bladder.

Case XXI (92462).—Mrs. M. D., aged thirty-three years, was examined September 22, 1913. She gave a three-year history of attacks of dull pain under the right costal margin and eructations of gas and food. During the intervals between attacks she was entirely free from any disturbance. During the preceding year the attacks had been quite

severe. The first operation, cholecystostomy, was done September 30, 1913. One stone was found in the gall-bladder. Three months after the operation the patient had a sudden attack of severe pain along the right costal margin radiating to the back. There was no vomiting, no jaundice, but some residual soreness. Two and one-half years after the operation the attacks became noticeably more severe, and cholecystectomy was done April 20, 1916. Cholecystitis with many stones in the gall-bladder was found.

CASE XXII (28466).—Mrs. H. F. D., aged thirty-five years, was examined September 1, 1909. There was a history of typical attacks of pain for six or seven years. The pain was severe, epigastric, and radiated to the back and right shoulder. A hypodermic injection was usually given. She had had three or four attacks a year, generally with vomiting. There was no mention of jaundice, fever, or chills. Cholecystostomy was done September 17, 1909. Numerous stones were found in the gall-bladder. She returned in May, 1916, having been well for four years, but during the past three years had had several attacks of severe upper abdominal pain with bloating and soreness. Morphine had been given to ease the pain. One week previous to her return she had had terrific pain in the epigastrium radiating to the back and right shoulder with vomiting, chills and fever. There had been continual aching and severe pain since that time and she gradually became more jaundiced; the temperature for three days was up to 103°. There was swelling over the area of the wound. An ice pack was applied and no food was allowed for three days. The second operation, a cholecystectomy, was done May 2, 1916. All of the gall-bladder except the bottom was removed. Acute empyema of the gall-bladder was found, the gall-bladder had ruptured at the fundus and there was an abscess in the abdominal wall and one deep in between the gall-bladder and omentum.

CASE XXIII (92367).—Mrs. G. H. P., aged thirty-eight years, was examined September 19, 1913. For three or four years she had had attacks of epigastric pain coming on every three or four months and lately she had had two or three each week, the last one three weeks previously. The pain was very severe, lasted several hours, and vomiting gave no relief. Morphine was required. The first operation, a cholecystostomy, was done April 24, 1913. A strawberry gall-bladder was found to contain numerous small mulberry stones. There was much thickening of the common duct and the pancreas was large and hard. She returned for examination in July, 1916. She had had no trouble for three years, and then began having attacks of pain which became more and more frequent—one each day. The pain started in the right epigastrium and radiated to the back, was very sharp, and required hypodermic injections. The symptoms were precisely the same as before operation. The stools were clay colored and she was apparently slightly jaundiced. The second operation, a cholecystectomy, was performed July 27, 1916. Chronic empyema of the gall-bladder and stones were found. The gall-bladder was thick-walled and reddened, with many adhesions about it.

CASE XXIV (46235).—Mrs. M. A. G., aged thirty years, was examined November 23, 1910. For the past two years she had had many typical attacks of gall-bladder colic. There had been no nausea, vomiting, or residual soreness and very little digestive disturbance. A cholecystostomy was done November 29, 1910. Stones were found in the gall-bladder. She returned in February, 1916. About eight months after her operation she had begun to have a repetition of her former attacks, lasting for several days at a time, with epigastric pain, considerable bloating and eructations of gas or food but no vomiting, chills or jaundice. A second operation, a cholecystectomy, was done February 15, 1916. A strawberry type of cholecystitis with papillomas in the walls of the gall-bladder and one cholesterin stone was found.

CHOLECYSTOSTOMY AND SECONDARY CHOLECYSTOSTOMY

CASE XXV (112866).—M. O., a male, aged forty-eight years, was examined August 11, 1914. He had had attacks of typical gall-bladder colic for three years, gradually becoming more frequent and severe. Hot applications afforded relief and morphine was given for severe attacks. There had been considerable bloating, vomiting at times, no jaundice and intervals of entire freedom from any signs of trouble. Cholecystostomy was done August 24, 1914. Acute cholecystitis and many stones were found. He returned in February, 1916. He had been well for one and a half years and then had what he termed a "bilious attack." There was no further trouble for six months, and then a severe attack of right upper abdominal pain, radiating to his back and right shoulder, nausea, induced vomiting of bile and mucus, but no chills, fever, or jaundice. He had had several similar attacks since that time. A second operation, a cholecystostomy, was performed February 17, 1916. A single mulberry stone was found in the gall-bladder and pancreatitis 2 on a scale of 4.

CHOLECYSTOSTOMY AND SECONDARY CHOLEDOCHOTOMY

CASE XXVI (146436).—Mrs. J. K., aged forty-one years, was examined November 23, 1915, giving a history of typical gall-stone colics fourteen years previously. Eleven days previously she had had a sudden severe attack of pain in the right epigastrium, had vomited bile, had chills, was jaundiced, and had a temperature of 99°. January 7, 1915, a cholecystostomy was done. A preliminary operation was performed on account of the patient's condition. A large distended gall-bladder filled with stones and a liver twice the normal size were found. A second operation, a choledochotomy, was done February 17, 1916, with the removal of numerous stones from the common and hepatic ducts.

CHOLECYSTOSTOMY, SECONDARY CHOLECYSTECTOMY AND CHOLEDOCHOTOMY

CASE XXVII (58500).—Mrs. M., aged forty-one years, gave a history of thirteen years of typical attacks of gall-stone colic with jaundice. The first operation, a cholecystostomy, was performed Sep-

tember 15, 1911. The gall-bladder was markedly infected and contained stones. After this operation the patient was well for five years and was then seized with typical gall-stone attacks with jaundice. September 5, 1916, cholecystectomy and choledochotomy were done. Cholecystitis was found with many stones in the gall-bladder, but no stones in the common duct.

CASE XXVIII (14675).—Mrs. S., aged thirty years. She had had typical gall-stone attacks for three months, but no fever or jaundice. Cholecystostomy was performed November 30, 1910, and many small stones were found in the gall-bladder. After this operation the patient was fairly well for five years, when, during pregnancy, there were occasional belching and bloating. In the last three months she had had attacks of typical gall-stone colic with chills, but no jaundice. A second operation, cholecystectomy and choledochotomy, was performed June 17, 1916. One rounded stone at the ampulla and marked cholecystitis were found but no stones in the gall-bladder.

CASE XXIX (183209).—Mrs. C. W., aged sixty-two years. She gave a six-year history of gall-stone colic without jaundice. First operation, cholecystostomy, was performed January 23, 1917. A ruptured gall-bladder was found containing stones and there was infection in the right anterior subphrenic space. She returned six months after this operation, having had three attacks of pain with jaundice, chills, and fever. A second operation was performed May 23, 1917. Cholecystectomy and choledochotomy were done. The common duct was very thick-walled and dilated, but contained no stones. There were cholecystitis, some stony débris in the gall-bladder and subacute pancreatitis.

OPERATIONS ON THE GALL-BLADDER (NOT INCLUDING THOSE FOR CARCINOMA) IN 1916 AND 1917

OPERATIONS ON THE BILIARY TRACT, 2027; MORTALITY, 2.9 PER CENT.

Type of operation	Cases per cent.	Mortality per cent.
Cholecystectomy	1621 (80)	1.9
Cholecystectomy and choledochotomy	217 (10.7)	3.2
Cholecystostomy	82 (4)	8.5
Cholecystostomy and choledochotomy	27 (1.3)	14.9
Choledochotomy	39 (1.9)	12.9
Reconstruction of the ducts	28 (1.38)	14.0
Miscellaneous	13 (.6)	15.3
Secondary operations	219 (10.8)	5.5
Cholecystectomy	120 (54.7)	.8
Cholecystectomy and choledochotomy	32 (14.6)	3.1
Cholecystostomy	4 (1.8)	50.
Cholecystostomy and choledochotomy	3 (1.3)	0.
Choledochotomy	35 (16.)	14.2
Reconstruction of the ducts	21 (9.5)	9.5
Miscellaneous	4 (1.8)	25.

SECONDARY OPERATIONS, 219; MORTALITY, 5.5 PER CENT.

	Cases per cent.
Cholelithiasis	109 (49.7)
Cholecystitis	153 (69.8)
Adhesions	148 (67.5)
Pancreatitis	441 (18.7)
Fistula	37 (68.8)
Strawberry gall-bladder	34 (15.5)
Jaundice	17 (7.7)
Trabeculation	11 (5.)
Stricture	8 (3.6)
Papilloma	7 (3.1)

Stones found at first operation in 154 cases; 70.3 per cent.:

	Cases Per cent.
In the gall-bladder in	140 (90.9)
In the ducts	9 (5.8)
In the gall-bladder and ducts	5 (3.2)

Stones found at the secondary operation, 109 cases; 49.7 per cent.:

	Cases Per cent.
In the gall-bladder in	59 (54.1)
In the gall-bladder and ducts	9 (8.2)
In the ducts	41 (37.6)

Previous operations on the gall-bladder in the Mayo Clinic, 64 (29.2).
Of the 64 cases, stones were found at first operation in, 51 (79.6).
Of the 51 cases, stones were found at second operation in, 35 (68.6).

64 SECONDARY OPERATIONS ON THE GALL-BLADDER IN 1916 AND 1917

TYPE OF FIRST OPERATION

	Cases
Cholecystostomy (for stones 29; cholecystitis 8)	37

TYPE OF SECONDARY OPERATION

	Cases
Cholecystectomy (for stones 13; for cholecystitis 5)	18
Cholecystostomy (for stones in the gall-bladder)	1
Choledochotomy (for stones in duct)	1
Choledochotomy and cholecystectomy (for stones or stony material in the gall-bladder or ampulla)	3
Cholecystectomy (for cholecystitis without stones)	6
Cholecystectomy (for stones or stony material in the gall-bladder 2 cases; for cholecystitis without stones 6 cases)	8

TYPE OF FIRST OPERATION

	Cases
Cholecystectomy (for stones 10; for cholecystitis 2)	12

TYPE OF SECONDARY OPERATION

	Cases
Stones at the first operation	10
Choledochotomy (for stones in the ducts 6; small ducts—adhesions infection 2)	8
Reconstruction of ducts	2
Choledochotomy (for partial obstruction of common duct—many adhesions and distended hepatic duct)	1
Reconstruction of the common duct (tremendous adhesions, but condition not sufficient to account for symptoms)	1

RECURRENCES AFTER BILIARY OPERATIONS

TYPE OF FIRST OPERATION

	Cases
Choledochotomy and cholecystectomy (for stones in ducts)	7

TYPE OF SECONDARY OPERATION

	Cases
Choledochotomy (for stones and bile sand in ducts)	6
Reconstruction and choledochotomy (stricture of common duct, and tumor of cystic duct)	1

TYPE OF FIRST OPERATION

	Cases
Choledochotomy and cholecystectomy (for stones in ducts and bladder)	3

TYPE OF SECONDARY OPERATION

	Cases
Choledochotomy (stone in the common duct)	1
Cholecystectomy (cholecystitis with multiple small cysts in the mucosa)	1
Cholecystenterostomy (tense gall-bladder filled with bile—fistula arising from the common duct—infection of the gall-bladder—much oozing from all the tissues)	1

TYPE OF FIRST OPERATION

	Cases
Choledochotomy (stones in the hepatic duct)	2

TYPE OF SECONDARY OPERATION

	Cases
Choledochotomy (greatly dilated ducts, no stones, pancreatitis 3)	1
Partial cholecystectomy (empyema of the gall-bladder, no stones, a great many adhesions)	1

TYPE OF FIRST OPERATION

Drainage of a subphrenic abscess (preliminary to further operation)	1

TYPE OF SECONDARY OPERATION

	Cases
Cholecystectomy and excision of the sinus tract for ruptured gall-bladder and stone in the sinus tract	1

TYPE OF FIRST OPERATION

	Cases
Reconstruction of the hepatic duct (biliary fistula, dense adhesions)	2

TYPE OF SECONDARY OPERATION

	Cases
Reconstruction of the ducts (hepatic duct opened at the point of union with the stomach—stone removed from the hepatic duct)	1
Opening in the hepatic duct much contracted; this was enlarged and the anastomosis separated	1

TYPE OF FIRST OPERATION

	Cases
Choledochotomy (stones in hepatic duct)	2

TYPE OF SECONDARY OPERATION

	Cases
Choledochotomy (greatly dilated ducts—no stones—pancreatitis 3)	1
Partial cholecystectomy (empyema of gall-bladder—no stones—great many adhesions)	1

TYPE OF FIRST OPERATION

	Case
Drainage of subphrenic abscess (preliminary to further operation)	1

TYPE OF SECONDARY OPERATION

	Case
Cholecystectomy (excision of sinus tract of ruptured gall-bladder and stone in sinus tract)	1

TYPE OF FIRST OPERATION

	Cases
Reconstruction of hepatic duct (biliary fistula—dense adhesions)	2

TYPE OF SECONDARY OPERATION

	Cases
Reconstruction of duct (hepatic duct opened where it was united to stomach and the stone removed)	1
Reconstruction of duct (the opening in the hepatic duct was much contracted and was enlarged—anastomosis separated)	1

TYPE OF FIRST OPERATION

	Cases
Cholecystectomy (for stones 10; for cholecystitis 2)	12

TYPE OF SECONDARY OPERATION

	Cases
Stones at the first operation	10
Choledochotomy (for stones in ducts 6; small ducts—adhesions—infection 2)	8
Reconstruction of ducts	2
Choledochotomy (for partial obstruction of common duct—many adhesions and distended hepatic duct)	1
Reconstruction of common duct (tremendous adhesions, but condition not sufficient to account for symptoms)	1

TYPE OF FIRST OPERATION

	Cases
Choledochotomy and cholecystectomy (for stones in ducts)	7

TYPE OF SECONDARY OPERATION

	Cases
Choledochotomy (for stones and bile sand in ducts)	6
Reconstruction and choledochotomy (stricture of common duct, and tumor of cystic duct)	1

TYPE OF FIRST OPERATION

	Cases
Choledochotomy and cholecystostomy (for stones in ducts and gall-bladder)	3

TYPE OF SECONDARY OPERATION

	Cases
Choledochotomy (stone in common duct)	1
Cholecystectomy (cholecystitis with multiple small cysts in mucosa)	1
Cholecystenterostomy (tense gall-bladder filled with bile—fistula arising from common duct—infection of gall-bladder—much oozing of all tissues)	1

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ACUTE DILATATION OF THE STOMACH FOLLOWING PROSTATECTOMY

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It is not my object to discuss the various theories that have been advanced from time to time regarding the etiology of this condition, for as yet the etiological factor or factors are unknown; nor is it my intention to review the literature of the subject, inasmuch as this has been extensively done recently by Lee, Colin, Laffer and Borchgrevink; but I shall report a case in which this condition followed suprapubic prostatectomy. Besides reporting cases occurring in the practices of the authors, the above-mentioned articles contain extensive bibliographies, Laffer having reviewed 217 reported cases and Borchgrevink analyzed 144 cases from the literature. Those interested in this subject are referred to these publications.

That acute dilatation of the stomach following suprapubic prostatectomy is a rare complication is evidenced by the fact that in the above-mentioned extensive reviews not one instance is mentioned in which this condition complicated suprapubic prostatectomy. Nor have I been able to find in the literature at my command a single recorded case, so that this case which I shall cite is probably the first to be reported in this country. The reasons for this scarcity of literature on this complication will be discussed below.

Therefore, the extreme rarity of acute dilatation of the stomach following prostatectomy seems to me to justify the reporting of the following case:

G. C. M., male, aged sixty-three, was admitted to the Presbyterian Hospital, September 23, 1916, referred by Dr. C. McCullough.

Past History.—The patient had the usual diseases of childhood. At the age of twenty-seven he had a Neisserian infection, which was followed by stricture and treated by the use of sounds. He has been troubled with frequency of urination for about fifteen years, being obliged to arise about once at night during all this time; of late, two or three times a night. The frequency is always worse during cold weather.

Present Complaint.—The patient comes in complaining of pain in the bladder and back and inability to urinate. During the past year there has been more or less difficulty in urination, so that the patient has had to strain in order to start the stream. The stream has been very slow and dribbling was present at the end of urination. There has been some pain associated with the straining, but no burning. Four days ago the patient had severe pain in the bladder and a dull

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aching pain in the back. At this time the patient was unable to urinate. He was catheterized and 50 ounces of urine were obtained. In twelve hours he was again catheterized and 50 ounces of urine were obtained. Patient has passed no urine for four days and has been catheterized since the onset of the present attack of retention.

Examination.—The patient is a large, well-nourished man. The pupils are equal and react to light and accommodation. The teeth are in rather poor condition and the tonsils are large. The thyroid is normal. The heart, L. H. B. is 9 cm. from the M. S. L., R. H. B is 2 cm. from the M. S. L.; tones are clear and regular. The liver border is palpable at the costal margin. The abdomen is large and distended, with the lower portion dull at the site of the bladder. The external genitalia are negative. The extremities are normal.

Rectal Examination.—The prostate is very large, soft and not tender. It is as large as a grape-fruit. On admission to the hospital the patient was catheterized and 52 ounces of urine were obtained. The catheter passed the prostate with difficulty. Blood-pressure: Systolic, 130; diastolic, 90. Urinalysis: Specific gravity, 1018, acid, trace of albumin, no sugar or acetone. Few fine granular casts, few pus-cells, but no blood. Röntgen ray examination: Negative for the presence of stones. Phenolsulphonephthalein test: Time of appearance, 11 minutes. Output first half hour, 27.8 per cent.; second half hour, 11.5 per cent.; total, 39.3 per cent.

Urinalysis (September 24, 1916): Cloudy, amber, 1025, acid, erythrocytes, +; leucocytes, + +; cell count shows 475 pus-cells per c.mm.

Cystoscopy could not be carried out as it was impossible to introduce the cystoscope because of the obstruction due to the enlarged prostate.

Suprapubic Prostatectomy (September 27, 1916).—Ether anæsthesia. An incision was made in the midline from symphysis to umbilicus. The peritoneum was stripped back from the bladder and the bladder opened. The prostate was enucleated in two minutes. The bladder was then packed for a few minutes. This was followed by a rather severe hemorrhage, which gave a great deal of trouble until it was controlled. This was done by packing the wound very tightly with gauze. The incision was closed with deep catgut sutures and silkworm-gut sutures closed the skin.

Post-Operative Course (September 28, 1916).—Dressings moist and very slightly tinged with blood. During the day the patient had four attacks of vomiting, vomiting at each time from 150 to 200 c.c. of greenish fluid. There was very little nausea.

September 29, 1916: Abdomen quite distended. At 8.30 A.M. the patient vomited 500 c.c. of a dark greenish fluid. The gauze packings were removed from the bladder. During the night he vomited a small amount of fluid and was still nauseated.

September 30, 1916: The patient had ten attacks of vomiting during the twenty-four hours. The amount vomited varied from 150 to 360 c.c. At 10.45 A.M. the stomach was aspirated and 400 c.c. of foul-

smelling fluid obtained. This was followed by gastric lavage with sodium bicarbonate. Eight hours later the patient had a second gastric lavage with sodium bicarbonate. At this time the pulse was rapid, of poor quality and the patient had some hiccough. The dressings were saturated with urine, but no blood.

October 1, 1916: The patient continued to vomit large amounts of foul-smelling fluid. At the first aspiration 300 c.c. of fluid were obtained. At the second, made seven hours after the first, 1500 c.c. of dark brown fluid were obtained. Each aspiration was followed by a gastric lavage with sodium bicarbonate.

October 2, 1916: Three aspirations were carried out. At the first, 1000 c.c. were obtained; at the second, 600 c.c., and at the third, 400 c.c. Each aspiration was followed by gastric lavage with sodium bicarbonate. The dressings were saturated with urine. The pulse was very poor.

The patient died at midnight October 3, 1916. The dressings were saturated with urine. The pulse could not be felt and failed to respond to stimulation. Unfortunately, an autopsy could not be obtained.

Besides gastric lavage, the patient was given digipuratum, strychnia and caffeine citrate, and normal saline solution per rectum and subcutaneously to make up for the loss of fluids.

The recent interest displayed in the subject of acute post-operative dilatation of the stomach has revealed the fact that this condition is not as rare as was formerly supposed. Certain phases of this subject remain unsolved, chief of which are the etiology and pathogenesis. Although one generally thinks of acute dilatation as a surgical complication, there are many instances in which this condition has occurred in patients who were not subjected to surgical intervention. Thus, cases do occur in strictly medical conditions, cases having been reported in which this occurred during pneumonia by J. B. Herrick, Houssen, Lehman, Box and Wallace and Leonhardt. Furthermore, cases have been reported that occurred during typhoid fever by Wichern, Baumler, Heine-Ewald and others. Albu reported a case occurring on the eleventh day of scarlet fever and Bloodgood a case that occurred after acute rheumatism. Not only has dilatation of the stomach occurred during the acute infectious diseases, but it has been seen in the course of chronic illnesses, such as pulmonary tuberculosis, diabetes and sciatica.

Trauma, such as a blow upon the abdomen, has been mentioned as a factor in a few instances. Even pregnancy may be complicated by gastric dilatation (Laffer, Thomson, Campbell), and in rare instances it has occurred after rupture of an extra-uterine pregnancy. Cases associated with overeating or the taking of large amounts of fluid, hasty eating, etc., have been reported by Bastedo, Hoffman, Brown, Körte and others. To this group may be added the cases occurring in infants. That infants do not escape this disease is evidenced by cases reported by Beck, Belilios and Cooper. Kundrat also called attention to its occurrence in infants.

These instances of its occurrence are briefly mentioned to show that this condition does occur independently of surgical operations. It is, however, as a surgical complication that dilatation of the stomach has received more clinical study, as most of the cases reported have followed surgical operations. By far the largest number of cases have followed operations within the peritoneal cavity. That it can and does occur after operations other than laparotomies is also well known, for cases have been reported which occurred after operations on the head, such as drainage of the antrum of Highmore, after operations on the extremities, as resection of the hip-joint, amputations and operations for osteomyelitis. Operations on the genito-urinary organs likewise have been followed by gastric dilatation. Thus this condition has been reported as following an external urethrotomy (Braun and Seidel), as well as operations upon the kidney (Borchgrevink, Legueu, Payer-nephrectomies, and Borchardt-nephropexy).

As previously stated in this paper I have not found a case reported in which this condition followed prostatectomy, and one is therefore forced to come to one of three conclusions regarding the occurrence of this condition as a complication of prostatectomy:

1. Either this entity as a complication of prostatectomy is very rare;

2. That the condition does occur but is not recognized—which from the gravity of the symptoms hardly seems possible;

3. Or that cases do occur, are recognized, but not reported because of their generally fatal termination.

THE MECHANISM OF OBSTRUCTION IN PROSTATIC ADENOMA

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of New York
ADJUNCT SURGEON, MT. SINAI AND LEBANON HOSPITALS

The mechanism of retention of urine in prostatic adenoma has not been adequately explained. During the past few years the conclusions reached by a number of investigators dealing with the mechanism of prostatic obstruction have been that prostatic enlargement is not the cause of prostatic retention. To support this contention, cases are cited to show that prostatic enlargement often occurs without retention. According to Sir Henry Thompson, not more than half of those with enlarged prostates suffer from retention. On the other hand, it is well known that retention often occurs without prostatic enlargement. This group of cases, the *prostatisme sans prostate* of Guyon and his followers and the distinct types of retention of urine due to central nervous diseases, will not be included in this discussion.

The usual varieties of obstruction at the bladder neck or in the prostatic urethra may be classified as follows:

1. Median lobe hypertrophy, including the pedunculated form.
2. Lateral lobe hypertrophy, without recognizable median lobe involvement.
3. General hypertrophy, involving all five lobes, or more particularly the lateral or median lobes.
4. Hypertrophy of the submucous glands of Albarran.
5. Contracture of the neck of the bladder, often termed the fibrous median bar.

The site of the obstruction in prostatic adenoma has been placed by some investigators at the neck of the bladder. According to Keyes,[1] a finger introduced into the prostatic urethra through a perineal opening encounters an abnormally elevated prominence on the floor of the urethra at the neck of the bladder. He believes that this prominence is the cause of prostatic retention. However, the precise manner in which this obstruction interferes with the urinary flow has never been definitely proven. According to some observers, this prominence interferes with the normal action of the internal sphincter and thus produces retention.

In considering other theories that have been advanced to explain retention, it may be said that some hold that the compression of the urethra by enlarged lateral lobes cannot in itself cause retention. In fact, it has been shown that instead of being strictured, the posterior urethra is more often dilated in prostatic adenoma and that frequently there is no obstruction to the passage of a large-sized catheter as it enters the bladder. This being

[1] Keyes, E. L.: The Mechanism of Prostatic Retention. Journal A. M. A., v, May, 1914.

the case, it would hardly seem possible that there could be any interference with the urinary flow. However, a condition somewhat similar to be found is contracture of the neck of the bladder. In this disease it is well known that a full sized sound may be introduced into the bladder without marked difficulty, and the patient nevertheless suffers from urinary symptoms and frequently from retention of urine.

It is obvious in looking for an explanation into the mechanism of prostatic obstruction in prostatic adenoma, that no one factor can be made to apply to all the forms of prostatic enlargement. In the small number of cases where a distinct pedunculated median lobe or hypertrophied Albarran submucous glands are present, the mechanism of retention is readily explained by the obvious nature of the obstruction. In the larger group of

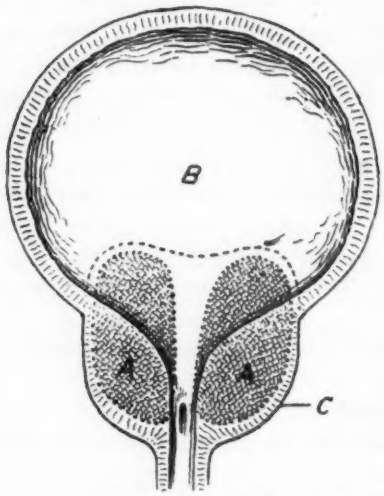


FIG. 3.—*AA*, adenomata in position of rest; *B*, bladder; *C*, resistant capsule.

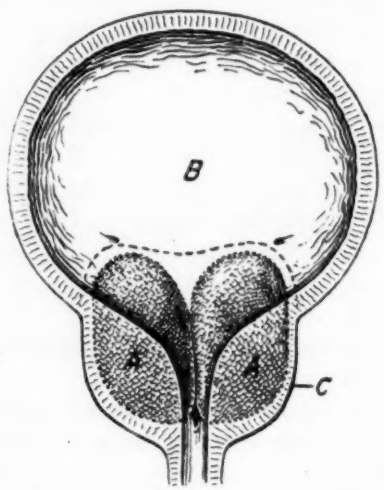


FIG. 4.—*AA*, adenomata compressed by hydrostatic (increased) pressure approximating on the broadened urethra; *B*, contracting bladder plus increased abdominal pressure; *C*, resistant capsule.

prostatic hypertrophies involving the lateral lobes the mechanism is entirely different. The site of the obstruction which is in the prostatic urethra can be readily demonstrated with a posterior irrigating urethroscope, or the close vision convex sheath of the Buerger-Brown cystoscope. The enlarged lobes of the prostate are distinctly seen as two generally symmetrical masses, lying on either side of the urethra extending from immediately beyond the internal urethral orifice to a short distance below the verumontanum. The urethra occupies a groove between these large masses. In normal respiration the lobes are separated from each other; in deep respiration they are seen to be farther apart, and a wider strip of the urethra is visible. When the patient is asked to strain, simulating the condition in urination against obstruction, the lateral lobes are brought into close apposition for practically their entire length, thus obliterating the lumen of the urethra. The prostatic adenomata acts as a potential obstruction in the posterior urethra. The intra-

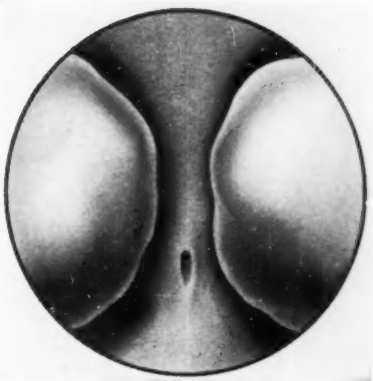


FIG. 1.—Urethroscopic picture of post-urethra in normal respiration.

FIG. 2.—Urethroscopic picture of post-urethra during act of straining.

abdominal pressure and hydrostatic pressure of the full bladder transform this potential obstruction into an actual one. During the act of micturition or straining the elastic adenomata are squeezed down, and being surrounded by a dense fibrous capsule, can give way in only one direction and that towards the prostatic urethra. Thus the lateral lobes are brought into close apposition shutting off the canal. Beer,[2] who first called attention to this mechanism, describes it as the "vocal cord" play of the prostatic lobes. His explanation of the manner in which the lateral lobes act in producing obstruction is as follows: "Under the increased intra-abdominal pressure the prostatic adenoma is forced down in straining into the prostatic capsule and the wide posterior urethra is compressed from side to side, thus producing obstruction to the outflow of the urine. This explains the fact so often observed in these cases, that "the harder they strain, the more difficult it is to empty the bladder." On the other hand, in those cases of moderate lateral lobe enlargement in which retention is not present one notices through the urethroscope that the lobes are not in close apposition in the act of straining, that the urethra is not compressed, and that there is a sufficiently large trough for the escape of the urine.

In conclusion, therefore, I am of the opinion that obstruction to the outflow of the urine in cases of lateral lobe enlargement is potential, and regularly due to blockage of the urethra by the lateral lobes during efforts of forced urination.

[2] Beer, E.: Adenoma of the Prostate. Medical Record, March 14, 1914.

TERATOMA OF THE SACRUM: GLIOMA OF THE UPPER ABDOMINAL CAVITY *

By James E. Thompson, M.B. (Lond.), F.R.C.S. (Eng.)
of Galveston, Texas

It appears to me that neoplasms should be studied from three distinct standpoints, the anatomical, histological and histogenetic. The anatomical appeals most to the practical surgeon, because it enables him to remove the growths safely and radically, and in so doing to satisfy both the immediate needs of the patient and his own standards of good work. Histological study follows closely on this, so closely, in fact, that in some clinics a histologic diagnosis is given to the surgeon before the operation is completed, and, if the case demands it, before complete removal of a tumor is attempted. Histogenetic study, *i.e.*, the study of the origin of the cells of the tumor, is usually relegated to the pathologist, receiving, I am sorry to say, but scant attention from the surgeon as being a matter of mere didactic interest, with little practical bearing. Such a mental attitude is to be deplored, because it shuts the surgeon completely out of the romantic atmosphere of his specialty and reduces him to a mere materialist. The reproach has often been hurled at surgeons that they were degenerating into clever craftsmen doing what they were told to do by the internists without personal knowledge of the reasons for operating. In some degree this reproach has been earned. The surgeons we revere most, like John Hunter and Billroth, were consummate pathologists.

If any apology is needed for the report of the two following cases, it lies in the hope of placing before you in as simple a manner as possible the etiology of the reported tumors from an embryological standpoint.

Case I.—*Teratoma of the sacrum.* A female white baby, aged six months, came under my care suffering from a large tumor attached to the lower end of the sacrum and coccyx. At birth the tumor was about the size of an orange. The baby was well nourished and continued to grow normally and steadily without any interference with the natural bowel movements. The tumor seemed to increase in size proportionately with the growth of the child, until the child reached the age of five months, when the parents became alarmed by rapid growth of the tumor. When the case came under my observation the tumor was as large as a cocoanut. It occupied the region between the lower end of the sacrum and the anal orifice, which latter was somewhat prominent and distorted. The growth was globular in shape, smooth in outline, elastic to the feel, and of homogeneous consistence. No cysts could be discovered. The skin was freely movable over its surface. It was

* Read at the meeting of the Southern Surgical Association, December, 1917.

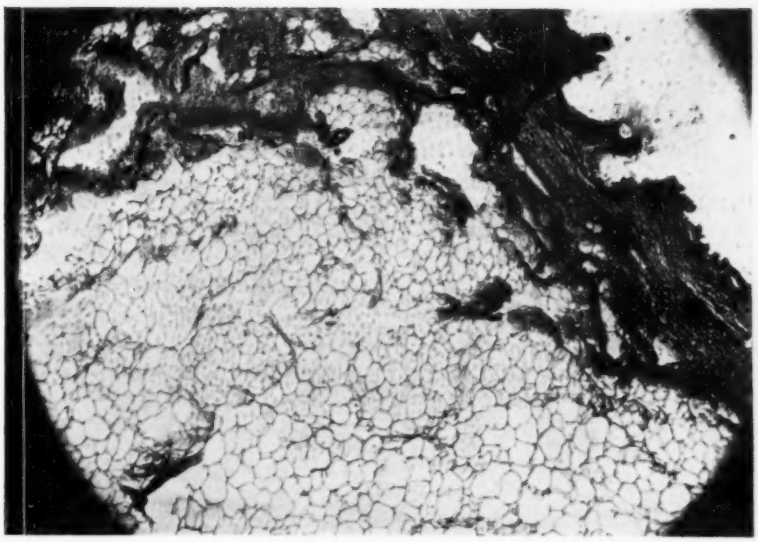


FIG. 1.—Shows fat composing the bulk of the tumor, like normal fat in appearance microscopically, but grossly very light in color. At one corner of the section is seen the wall of a cyst with epithelial lining. Later figures will show this cyst wall more perfectly.

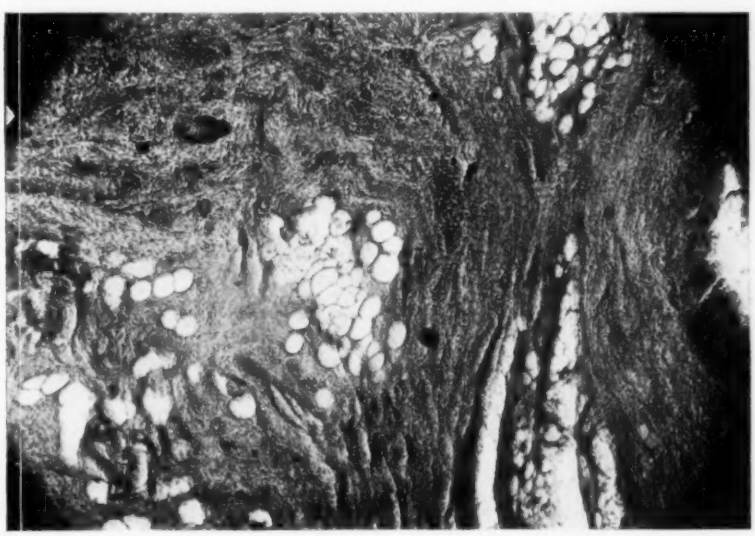


FIG. 2.—Shows an area of fibrous tissue, embryonic in type, infiltrating the fat. Grossly this is white fibrous tissue similar to that in the fibroma molle found in the uterus. This is slightly softer and more cellular than adult fibrous tissue. Mixed with it are some areas of fatty tissue.

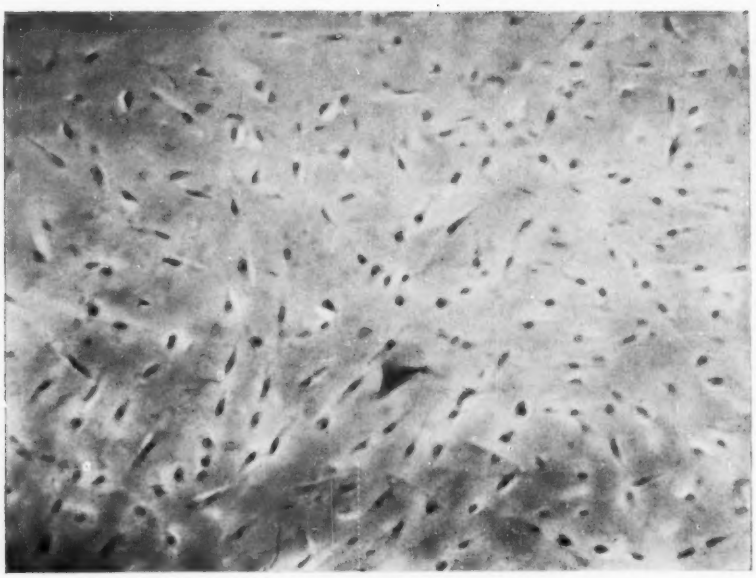


FIG. 3.—This figure shows cartilage, embryonal in type, similar to adult hyaline cartilage but containing more cells. This and the two preceding figures are of mesodermal origin.

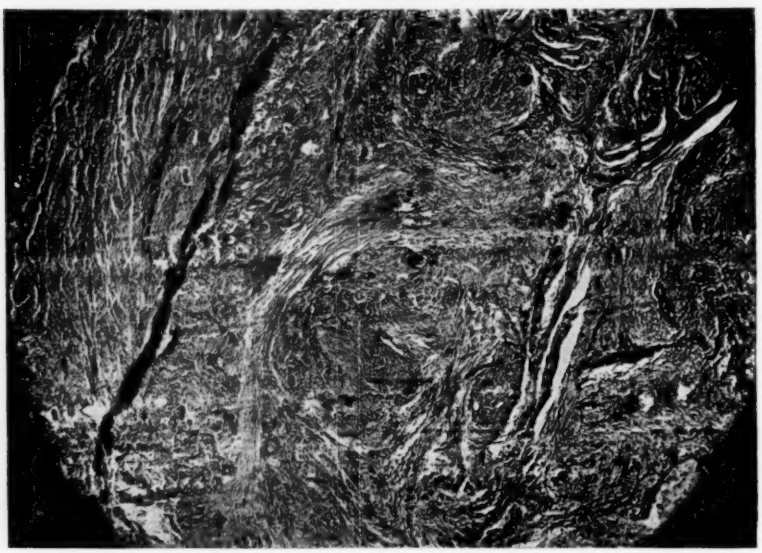


FIG. 4.—This section is taken from one of several small irregular areas, grayish pink in color, imbedded in the fat of the tumor. One or two of these contain small cystic cavities. Microscopically, as will be seen from the section, these areas resemble neuroglia. In the gross specimen, also, their color and appearance is very suggestive of nervous rather than of fibrous tissue.

FIG. 5.

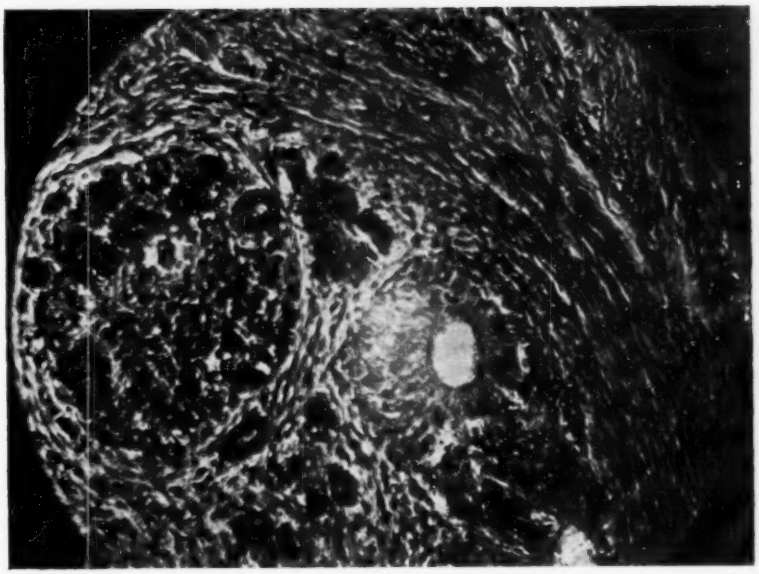
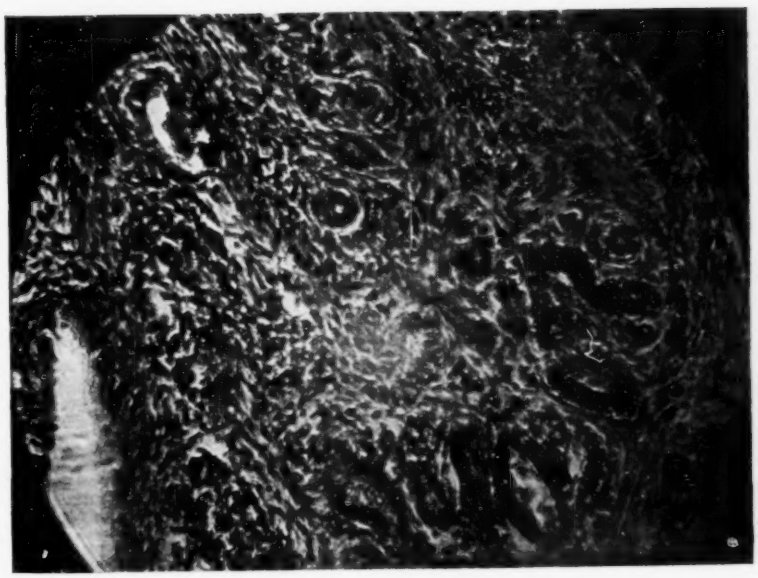


FIG. 6.



FIGS 5 and 6.—Higher power pictures of the same area. In these some of the cells have a definite ependymal character, being arranged in a radial manner. Only a neuroglia stain would differentiate these areas positively from gland tissue; but the conjunction of cells arranged in this way with tissue so much like gliomatous tissue is fairly definite evidence of their glial character, and if glial, they are of ectodermal origin.

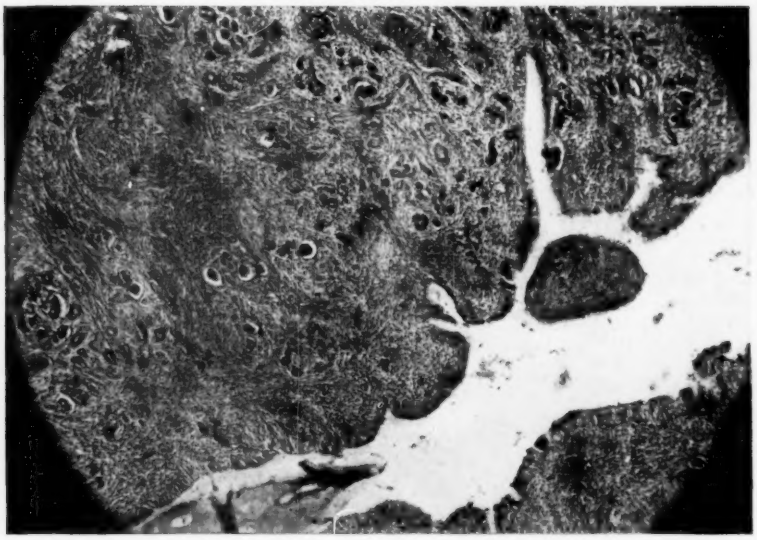


FIG. 7.—This shows the wall of a papilliferous cyst imbedded in the fatty material, containing a thick, tenacious, clear mucus, like normal mucus and not like the mucoid or gelatinous material usually found in tumor cysts. This tissue is suggestive of gastro-intestinal mucosa and therefore seems to be hypoblastic in origin. Unfortunately, mesoblast also gives rise to mucous glands (uterus, *e.g.*). The lining epithelium is simple columnar with goblet cells and simple tubular glands opening into the cyst. Deep in the tissue, it is difficult to tell whether the radial collections of cells are glandular or ependymal; the differential neuroglia stain is very uncertain in its results and an attempt made upon this was a failure—failing, also, in spinal cord—so that it proved nothing. In places the epithelium lining the cyst walls is stratified squamous.

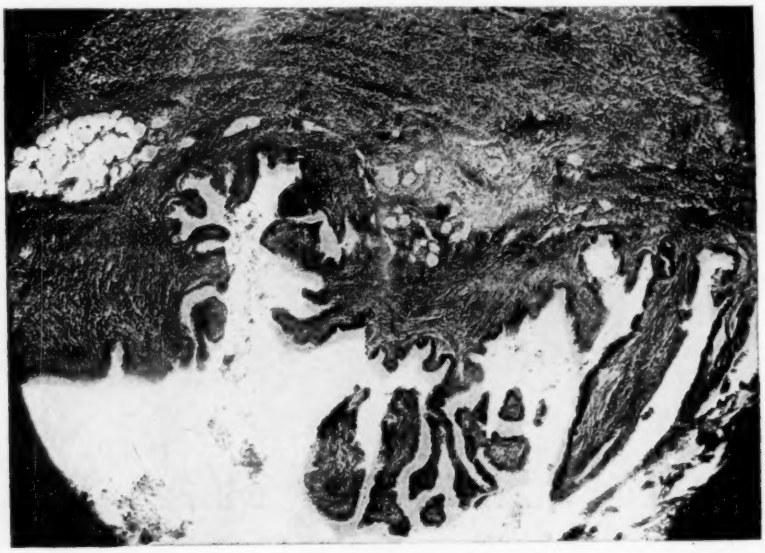


FIG. 8.—This shows another section of a cyst wall, a part of the same cyst in which the deeper layers are more definitely fibrous. The papilliferous arrangement is very accentuated.

firmly fixed to the sacrum and coccyx. Digital examination of the rectum revealed nothing abnormal. The mucous membrane was intact and free from signs of infiltration. It could not be moved freely from the growth. X-ray examination was negative as to the presence of bony or calcareous masses. A diagnosis of congenital sacral tumor was made.

Operation (February 11, 1915).—Ether anæsthesia. A transverse incision was made over the middle of the growth and the skin retracted upward and downward. The dissection was comparatively easy. The lower end of the sacrum was divided and the growth enucleated from above downward. In this way the rectum was exposed high up, as in a Kraske operation, and the deep dissection carried out under the eye. The rectum was not seriously hurt, only a trifling amount of muscular tissue being removed with the growth. The sphincter muscles were undisturbed. Convalescence was ideal, being unattended by any disturbance of the rectal functions. At the present time of writing (December, 1917) the child is in perfect health.

Description of Tumor.—The tumor was as large as a cocoanut and showed the lower part of the sacrum and coccyx spread on its posterior wall. On section, it appeared for the most part of a yellowish-white color, and of a firm homogeneous consistence. It looked like dense fat. Numerous serial sections were made which for the most part presented the appearances described below. In addition, a number of islands of cartilage were found, one of them being of considerable size; also a few smaller islands of irregular shape and of a grayish-pink color which strongly resembled the tissue of the brain; and also a number of cystic cavities, one of which was of considerable size.

The microscopic features are shown in Figs. 1–8, for which and the attached legends I am indebted to my friend and colleague, Dr. V. H. Keiller.

The case conforms to the type of congenital sacral tumors that have been hitherto described,[1] *i.e.*, it contains elements of all the three embryonic layers (*epiblast;* neuroglia: *hypoblast;* glands: *mesoblast;* fat, fibrous tissue and cartilage).

The exact origin of these growths has never been settled definitely. The theory usually advanced is that they are derived from the vestiges of the neuro-anal canal and the post-anal gut. Another theory, viz., that they are the result of fetal inclusion, has little to recommend it, because there is no reason why fetal inclusion should occur in this particular part of the body.

In all probability the real explanation is to be found in unusual and misplaced activity of the posterior growing point of the embryo. This theory is defended strongly by Adami, whose able arguments and clear reasoning appear to settle the question conclusively. The following description is taken from his text.[2] It is based on our knowledge of the growth of a plant. "If we consider that the first cell divides into two and then into

[1] Schwalbe: Morphologie der Missbildungen.

[2] Adami: Text-book of Pathology, p. 815.

four, and each of the four again into two, we find that the two poles tend to become separated one from the other and each pole is advanced by the cells that are built in behind it. There are in the plant, from an early stage, two primary growing points—the superior forming the stalk and the inferior the root; the entire plant arises from one or other of these 'points' and the growing point is the most advanced part of the plant; the plant increases by growth backward and not forward from the growing point whose position is thus fixed at its apex.

"The growing point does not grow forward, but is projected forward by the intercalation of the daughter cells behind it and the daughter cells are able to divide in a transverse way and give rise to special tissue cells. Secondary growing points can subsequently arise from the daughter cells, but their vegetative function must be exercised now in a direction more or less lateral and no longer axial. Similarly in animals, there are two 'growing points': the superior growing point is represented in the adult mammal by tissue about the situation of the pituitary body, and the inferior by tissue somewhere in the sacral region. These two points lie beyond the extremities of the chorda dorsalis, an organ whose prominence in the early embryo and whose apparent unimportance in the formed fœtus suggest that its function may be partly the keeping of the growth axially, as a scaffolding might do in the earliest stages. These two growing points from the very origin of the embryo are being projected apart, and the successive daughter cells given off from these give origin to the different organs of the body and even form secondary growing points for the limbs." . . . "But there is a fundamental difference to be observed. Whereas in the plant the primary growing points are active during the whole of its existence, in the animal they cease to functionate as such when the anlagen of the brain and the rest of the nervous system have been developed.

"The cells of the growing points consist of totipotent cells which are capable of giving rise to tissues of all orders belonging to the three primitive germinal layers. If, therefore, the growing points continue active, large masses of such tissue may be formed at either end of the body. These masses may contain bone and soft tissues representative of meso-, epi- and hypoblast. Those occurring at the anterior end of the body arise from the base of the skull just behind the pituitary fossa. They are spoken of as epignathus. Those at the posterior end of the body are situated at the lower end of the sacrum and form the congenital sacral tumors."

CASE II.—*Glioma of upper abdominal region.* C. A., aged thirty-nine, male, colored, was admitted to the John Sealy Hospital on November 21, 1917, suffering from a large tumor situated in the upper abdominal region.

History of the Disease.—About four months ago he noticed that his stomach was becoming bigger. He was then a large man, weighing about 200 pounds, and as he suffered from no pain or other discomfort he thought he was getting fatter. The tumor grew rapidly and he

lost about fifty pounds of weight in four months. He believed it showed itself first in the neighborhood of the umbilicus. There was no fever. It was his first sickness, so he did not seek advice, until the size of the tumor alarmed him. The day before admission to hospital he had slight pain over the tumor, which spread to the pit of the stomach and over the left side of the chest.

Previous History.—Gonorrhœa at the age of twenty-one. No history of syphilis; had been an unusually strong and healthy man. No history of dyspepsia or any stomach trouble.

Present Condition.—The patient looked fairly well nourished and weighed about 150 pounds. He complained of nothing but the inconvenience of the abdominal tumor. It was not painful, nor was it tender on reasonable manipulation. The tumor was large. It reached from about two fingers' breadth below the umbilicus to the upper part of the epigastrium, the left side of which it filled. To the right it reached the middle of the rectus abdominis muscle. To the left it filled the upper abdominal space and occupied completely the left epigastrium and hypochondrium. The percussion note was dull over the whole area and no shades of difference could be detected in its various parts. It did not move appreciably with respiration. It seemed to be firmly fixed to the posterior abdominal wall. The surface was roughly nodular. There was no pulsation.

Urine examination: Acid; specific gravity, 1012; sugar negative; albumen, a distinct ring; no casts. *Blood examination:* Red cells, 3,944,000; white cells, 6,200; hæmoglobin, 80 per cent.; polymorphonuclears, 50 per cent.; lymphocytes, 49.5 per cent. Wassermann reaction, strongly positive. No examination was made of the stomach contents.

Diagnosis.—A tentative diagnosis of retroperitoneal sarcoma was made and an exploratory operation was performed on November 24.

Operation.—A large angular incision was made, the vertical cut passing downward through the inner edge of the left rectus from the epigastrium to the umbilicus, and the lateral cut from the lower end of the vertical upward and backward to the tip of the twelfth rib. This gave a full exposure. The growth was found free from attachments to the transverse colon or to the right half of the stomach. It seemed to have pushed its way forward between the greater curvature of the stomach and the transverse colon. It was very nodular and cystic. It was covered in front by a thin layer of omentum in which very large veins coursed. Followed to the left it fused with the spleen. To the right it was free. Posteriorly it could be lifted from the aorta. At first it looked an impossible task to remove it; but after division of the omentum which covered it in front and opening the lesser sac and lifting up the stomach it was possible to separate it from all the anterior surface of the pancreas except about two inches of its tail. The left edge of the growth appeared to be jammed tightly between the tail of the pancreas and the spleen. The greater curvature of the stomach was also adherent to the growth over a small area. The tail of the pancreas and the splenic vessels were isolated and clamped, and a clamp was placed on the greater curvature of the stomach and the

growth removed with remarkably slight hemorrhage. A careful examination of the other abdominal organs revealed no abnormality. A drain was placed near the stump of the pancreas and the abdomen closed. Convalescence was unattended by any irritating discharges.

After History.—The patient returned to his work as a drayman six weeks after the operation and since that time has worked every day without fatigue. On October 15, 1917, I examined him carefully. There was no symptom of recurrence. He was sound and robust and weighed 157 pounds. *Blood count:* Red cells, 3,944,000; white cells, 6,200; polymorphonuclear neutrophiles, 50 per cent.; lymphocytes, 49.5 per cent.; transitional forms, 0.5 per cent.; hæmoglobin, 80 per cent. *Urine:* Straw colored, acid, specific gravity 1012, distinct ring of albumen, no sugar, a few leucocytes, amorphous urates, a few clear epithelial cells. Wassermann reaction, strongly positive, 4+.

Description of the Tumor.—The specimen removed was as large as a Rugby football. It consisted of the tumor, of the tail of the pancreas, the spleen, and a part of the greater curvature of the stomach. Both spleen and pancreas were tightly spread over the left edge of the tumor. Neither organ seemed to be infiltrated. The stomach wall was infiltrated and the growth projected slightly into the lumen. The tumor was very irregular in outline and its surface was nodular. Numerous blood cysts bulged from its surface. Its blood supply appeared to be derived entirely from the splenic vessels.

Section of the tumor showed numerous cysts of a large size separated from one another by septa of considerable thickness. The cysts contained blood in various stages of disintegration. Its color was mainly of a deep maroon tint. There was no gross evidence of intracystic growths. The septa consisted for the most part of tissue of a yellowish-pink color and firm consistence in which were found numerous areas of blood extravasation also of a deep maroon color. These septa evidently represented the main part of the original tumor. The gross features are well represented in the plate (Fig. 15).

The microscopical characteristics are shown in Figs. 9–14.

The pathological interpretation of the tumor is entirely our own, but we feel a little hesitation in insisting on our view obstinately. I have submitted the slides to my friend and former colleague, Dr. Allen J. Smith, of the University of Pennsylvania, whose opinion is that it probably resembles a chordoma which has undergone a sarcomatous change.

NOTE.—Early in January, 1918, the patient was readmitted to hospital with numerous widespread recurrences of the growth in the abdominal cavity. No further operative treatment was justifiable.

If the gliomatous nature of this tumor is admitted it probably takes its origin from one of the sympathetic plexuses of the upper abdominal cavity, in this particular case the plexus splenicus. Tumors of large size have been found arising in the upper abdominal cavity from these plexuses and from the adrenal gland which on microscopical examination have shown ganglion cells, axones and dendrites (Adami).

We have not been able to find indubitable evidence of ganglion cells, although in one specimen an area was found in which several bipolar cells strongly resembling ganglion cells were clearly distinguished.

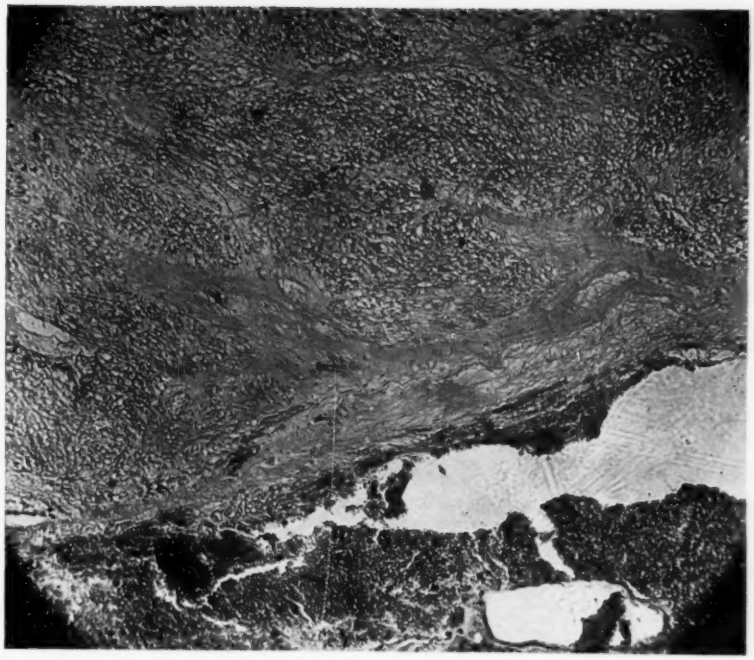


FIG. 9.—Shows a section taken through the wall of one of the blood clots in the tumor. It contains a portion of the clot. It will be seen that there is no epithelial lining to the blood space, nor is there any epithelium lining other cyst-like cavities containing gelatinous substance, which are found elsewhere in the tumor. The lighter portion of the slide shows collections of fine, faintly pink stained fibrillæ which I interpret as neuroglia fibrils, since they do not take a connective-tissue stain with Van Gieson's fluid. The darker portions represent collections of glial cells.

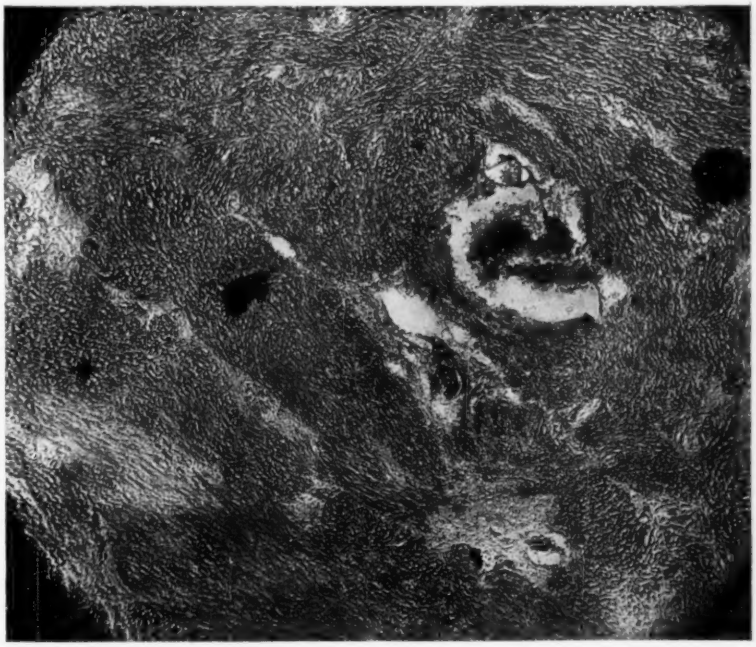


FIG. 10.—Shows another area of tissue, containing one small hemorrhage about the middle of the slide and several of the lightly stained collections of neuroglia fibrils. In the darker, more cellular portion of the section, some of the cells have a radial arrangement, suggestive of ependymal cells. Such an area, marked with a small cross, is shown in higher magnification in the following figure.

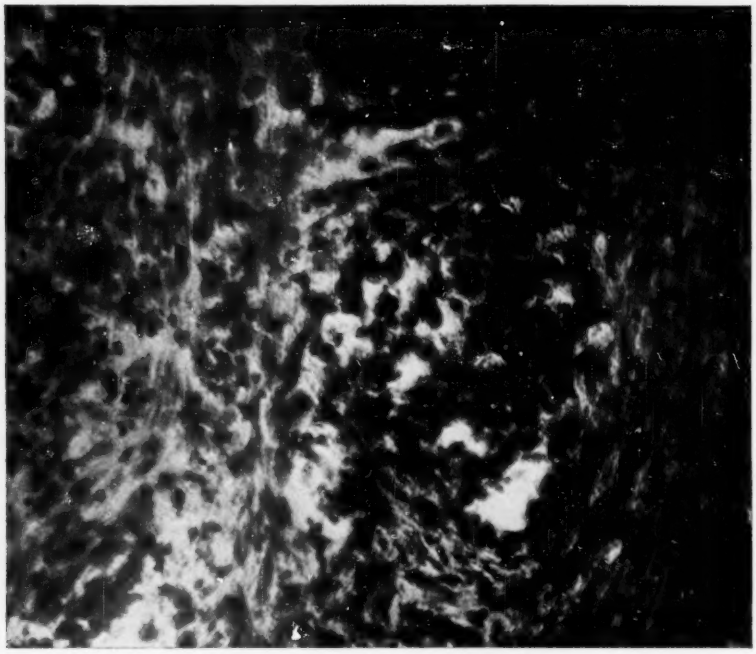


FIG. 11.—Higher power photograph of one of the radial collections of cells indicated in Fig. 10, and strongly suggestive of ependymal cells.

FIG. 12.—Another very low power photograph from the opposite end of the tumor, taken to emphasize the uniformity of its structure. Here again are light areas containing few cellular elements, and probably representing collections of neuroglia fibrils. In the more cellular portions are groups of round cells, some of them arranged in a radial manner, and many collections of spindle-shaped cells with indefinite outlines, of which higher-power pictures follow.

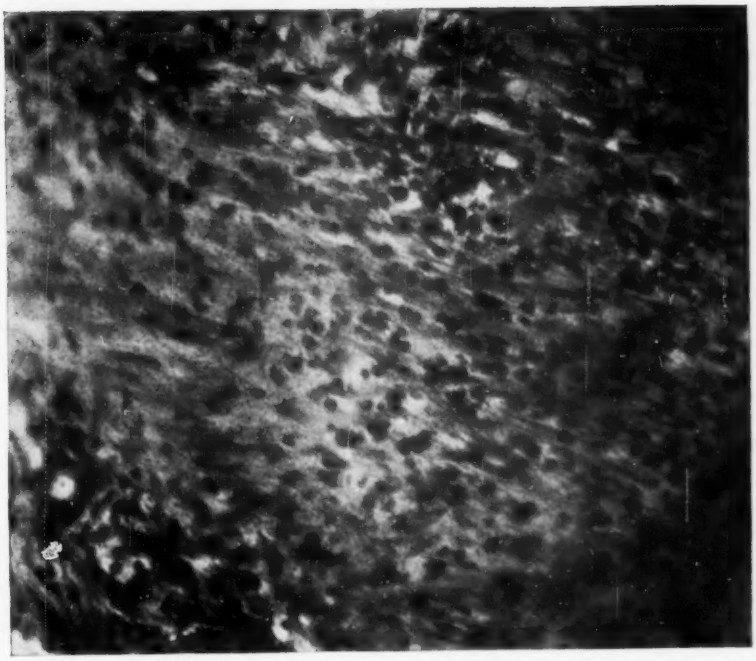


FIG. 13.—High power picture of a portion of the section just shown. These areas of round and spindle cells mixed together are very much like sarcoma and probably indicate sarcomatous change in the glioma.

FIG. 14.—High-power photograph of another area from Fig. 12, showing a collection of indefinite spindle cells, very suggestive of glial cells.

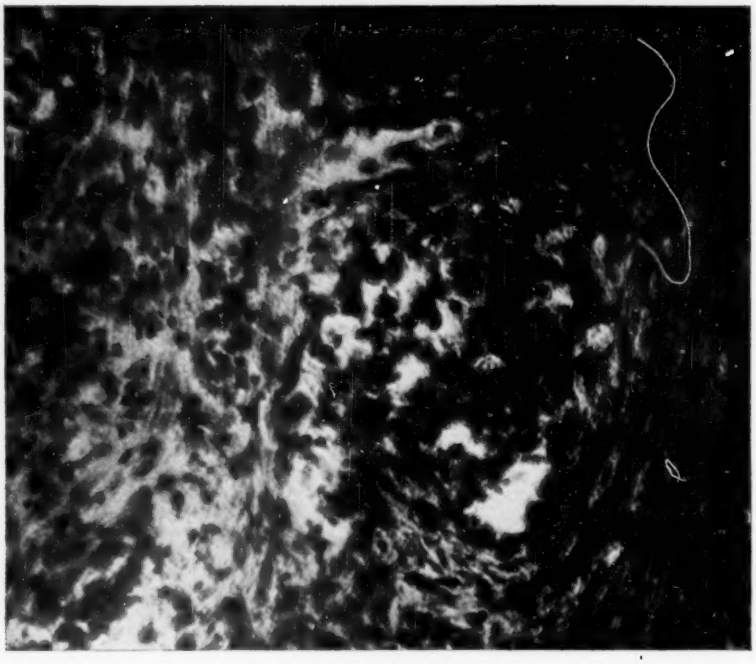


FIG. 11.—Higher power photograph of one of the radial collections of cells indicated in Fig. 10, and strongly suggestive of ependymal cells.

FIG. 12.—Another very low power photograph from the opposite end of the tumor, taken to emphasize the uniformity of its structure. Here again are light areas containing few cellular elements, and probably representing collections of neuroglia fibrils. In the more cellular portions are groups of round cells, some of them arranged in a radial manner, and many collections of spindle-shaped cells with indefinite outlines, of which higher-power pictures follow.

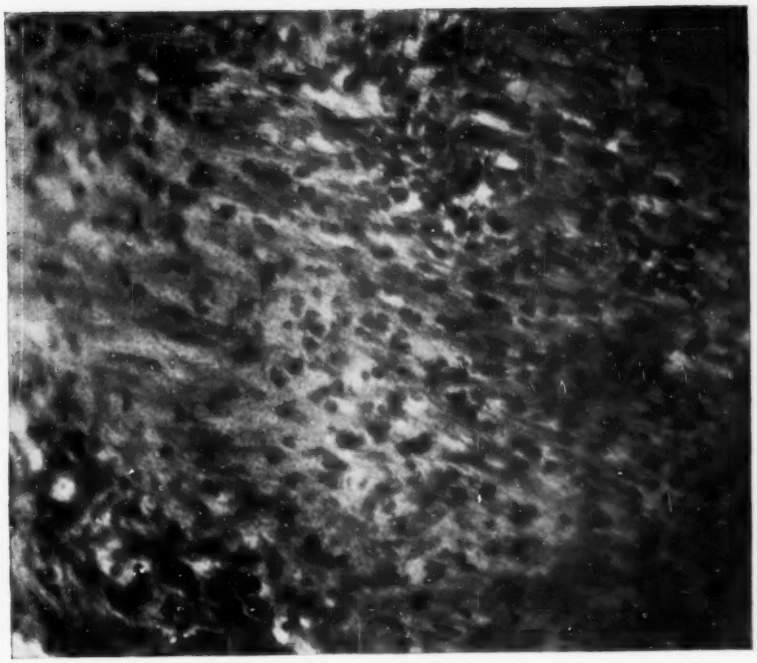


FIG. 13.—High power picture of a portion of the section just shown. These areas of round and spindle cells mixed together are very much like sarcoma and probably indicate sarcomatous change in the glioma.

FIG. 14.—High-power photograph of another area from Fig. 12, showing a collection of indefinite spindle cells, very suggestive of glial cells.

FIG. 15.—Section of the glioma of the upper abdominal region. The black areas represent blood cysts and blood extravasations. The white areas represent the intrinsic tissue of the tumor. Notice that it is mottled with small extravasations of blood.

REPAIR OF COMPLETE RECTOVAGINAL LACERATIONS*

By Irving S. Haynes, M.D.
of New York

The successful treatment of complete rectovaginal laceration is of such importance as to justify the publication of any procedure that makes such success more certain.

The entire absence from standard books on pelvic surgery of any operation for the repair of such extensive lesions is an added reason for placing the following report on record. The operation hereinafter described is one that I performed in January, 1916, for the repair of a total division of the rectovaginal septum from the cervix to and through the perineum.

The patient was an Italian woman, thirty-five years of age, who was brought to Harlem Hospital on January 12, 1916.

About two weeks before she had been delivered of a large child. During the process of extracting the baby she was completely torn as stated and the baby died.

The patient was mildly septic. Examination showed that the entire rectovaginal septum from the cervix to and including the perineum had been completely torn through in the middle line. The rectum and vagina constituted but a single canal that was filled with fæces and purulent discharge. With this exception the woman was strong and healthy. After a preparatory treatment of douches I performed the following operation:

The patient was anæsthetized and placed in the lithotomy position. The common rectal and vaginal canal was opened by retractors. The edge of the torn rectovaginal septum was covered with healthy granulation tissue.

Beginning at the centre of the tear the rectal wall was separated from the vaginal, being careful to reach the compartment between the rectovaginal fascia and the rectum. The dissection was carefully carried out downward, separating the rectum and anal canal from their attachments. When the anal margin was reached the mucous membrane was severed from the skin. The attachments of the levator ani and external sphincter were noted. This mobilization of the rectum was carried upward to the level of the sacral promontory, several inches above the torn septum. The peritoneum was opened from the cul-de-sac upward as far as the above separation of the rectum. There was no hemorrhage. This wide mobilization of the rectum permitted the bowel to be easily drawn downward until the upper margin of the fistula was beyond the level of the anal skin.

Inasmuch as the external anal sphincter had contracted to about a third of its usual size, the anococcygeal body had to be split to within

* Read before the New York Surgical Society, February 13, 1918.

half an inch of the coccyx, in order to properly accommodate the rectum which was now rotated through 90 degrees and sutured into position with the fistulous border well beyond the surface of the skin. Chromic gut sutures were used for the sutures passing from the surface through the bowel. Plain gut sutures to attach the levator ani to the gut in its new position. A drain of rubber tissue was placed in the posterior angle of the wound. The excess of rectal tissue, about 3 inches, was trimmed off and the skin and mucous membrane sutured together. The peritoneum was attached to the downward displaced rectum.

The operation was completed by suturing together, with kangaroo tendon, the levatores ani and perineal body as in an extensive perineorrhaphy. Over these sutured parts the vaginal wall was closed. Healing was uneventful. The patient was discharged on February 10. She had bowel movements without difficulty.

In the following July she came to see me complaining of difficulty in defecation. This was due to a tight stenosis of the anus. The stricture was relieved by an incision directed posteriorly.

In November, 1916, she again reported to me, stating that she was two months pregnant and frightened nearly to death. She was kept under observation and delivered of a living child by Cæsarean section on June 5, 1917, at Harlem Hospital, by Doctor Cherry, Assistant Visiting Gynæcologist. During this operation the opportunity was taken to resect the tubes.

Over two years have now elapsed since the repair of the total rectovaginal laceration. She claims she is perfectly well. Naturally, after such extensive mobilization of the rectum, the nerve supply to this bowel must have been seriously damaged. While this must have been true, some sort of a reflex mechanism must have later been developed because the patient claims she knows when her bowels are going to move and she has no difficulty in controlling the movements, only she must not wait too long after the call comes. The bowel opening has contracted considerably, but she refuses to have it enlarged, saying it is all right.

I have not made a complete search of the literature, but from the library of our Academy of Medicine I have found no method described for the repair of such an extensive tear as I have related. None of the standard text-books make any reference to the condition, except Ashton, who advises how inoperable cases should be treated by douches, sitz-baths and a constipating diet.

Segond,[1] in 1895, and A. Palmer Dudley,[2] in 1902, described the method they had used for the treatment of a rectovaginal fistula just below the cervix. Their operations are identical and consisted in freeing the anterior wall of the rectum from the anus upward until above the level of the fistula, bringing down this anterior wall until the rectal part of the fistula was out-

[1] Segond: Ann. de Gyn., Paris, 1895, vol. xliv, pp. 1–4.

[2] Dudley, A. Palmer: Jour. A. M. A., 1902, vol. xxxix, pp. 185–190.

side of the anus, suturing the gut in this position, trimming off the excess of rectal tissue and finally closing the defect in the vagina. Both had perfect cures.

Ligueu,[3] in 1903, described an essentially similar method for the treatment of a high rectovaginal fistula, only, he approached the fistula through a transverse incision between the anus and vagina as for a perineorrhaphy. The work of these surgeons was unknown to me until I began looking up the subject for this paper, even if there is a slight similarity between their method and mine, I think I may fairly claim originality for the conception and execution of a successful method for the treatment of complete rectovaginal lacerations.

I would emphasize the following steps:

1. Begin the separation of the rectum from the vagina just above the levatores ani and in the space between the rectovaginal fascia and the rectum.

2. Separate the bowel downward through the anal canal and cut through the mucocutaneous junction. Carry the mobilization of the bowel upward high enough to obtain sufficient sound rectum so that the undamaged rectum may be drawn beyond the level of the skin.

3. Divide the anococcygeal tissues sufficiently far towards the coccyx to permit suturing the retracted sphincter ani externus in front of the rectum.

4. Rotate the rectum through 90 degrees and suture it in place, especially reforming the attachments of the levatores ani to the bowel. Trim off the excess of rectal tissue and suture the skin to the rectal mucosa. Drain the region behind the rectum.

5. Complete the operation by a perineorrhaphy.

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[3] Ligueu: Bull. et Mem. Soc. Chir. de Paris, 1903, vol. xxix, pp. 793.

CANCER OF RECTUM*

By Jerome M. Lynch, M.D.
of New York
Medical Reserve Corps U. S. A.

Cancer of the rectum and colon has increased one hundred per cent. in the past fifteen years according to the report of Vital Statistics of the Registration Area of the United States. Bloodgood has well said that in the life history of every malignant growth there has been a moment when it was surgically curable and the lesions under consideration offer no exception to this admirable axiom. To recognize and to seize upon this precious moment is no less than to control the life destinies of the affected individual.

Results of Surgical Treatment.—Of 491 cases studied we have operated upon 335. The hospital mortality was 16 per cent. Forty-one have lived one year; 45 two years; 33 three years; 22 four years; 26 five years and 17 six years.

Patients not replying to circular letter have been classified as dead when last heard from. As in all clinics situated in cosmopolitan centres where the population is in constant flux, it is impossible to follow a large number of the patients. Thus the statistics as above created are necessarily less favorable than if every case had been followed to date.

Whatever disability exists as results of operation does not interfere with livelihood gaining. One of our patients who was bankrupt when his rectum and sphincter were removed, and who leaks at times, now makes four trips to Europe and has earned over a million dollars since operation. We cannot overemphasize the plain fact that post-operative conditions, no matter how unfavorable as to function, do not interfere with the usefulness or economic independence of the patient.

Incontinence is a relative term. Its importance has been grossly exaggerated. As no horse is sound, so no human body is without defect, and even great defects are compensated for by the natural endowment of the individual to meet such obligations. It is simply a question of getting used to the discomforts of a colostomy or a leaking anus—a psychological phenomenon well worthy of consideration. Think of the innumerable women torn in childbirth who have been incontinent for a quarter of a century, yet who efficiently and without affront to their families perform their daily work. Because of this psychological element we strongly prefer to have a relatively incontinent normal anus rather than upon the abdomen. This, briefly, is the result of surgical therapeusis in our series.

What stronger argument could there be for discussing the diagnosis and the indications? These statistics show that rectal cancer operated upon even after great delay and by poor methods is not hopeless. If with these

* Read before the American Gastro-Enterological Assn., May, 1917.

limitations we get results, how important, therefore, is the early diagnosis and how promising the outlook for the future.

What have been the methods of study in this series of 491 cases? Of first importance is a flat contradiction of some still prevailing convictions, to wit: That the operation is hopeless; that the cancer patient is cachectic or has lost weight; that age is of importance; that pain is a prominent symptom and that a tumor can always be felt. The very occurrence of these symptoms spells inoperability.

What are the important symptoms from the modern standpoint in order of diagnostic and therapeutic importance?

First, constipation: This we believe to be the very first and earliest of all symptoms. It is undoubtedly protective in type, being perhaps the result of biologic reaction to the influence of the new-growth. There are, however, several hypotheses as to its origin depending upon the path of inhibitory

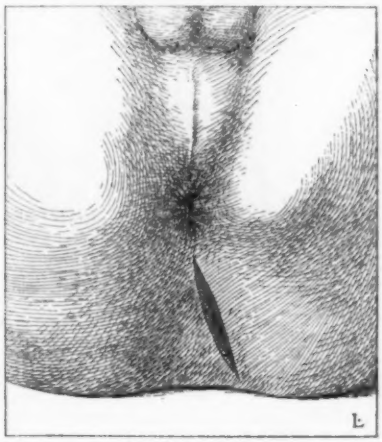

FIG. 1.—Shows where the first incision should be made when performing a perineal operation.

transmission rather than upon its origin or occurrence. Of the latter and of its protective nature there can be no doubt. Certainly it is not due to mechanical obstruction of the growth.

Second, stomach symptoms: We have repeatedly referred to these as esoteric as contrasted to hemorrhage and the like which are exoteric. Chronic indigestion, so frequent a sign of peripheral pathology, is just as significant of rectal cancer as of a chronic appendix.

Third, blood or bloody stools: This is usually the first exoteric sign. It can occur without ulceration, in which case it may be due to a blocking of the return circulation in the valveless veins leading to the liver. In any event hemorrhage so commonly associated with cancer (10 per cent. of our cases of 491 had been operated upon previously to our seeing them for hemorrhoids) is a frequent source of the blood. In a large proportion of the cases, however, it is due to ulceration.

Fourth, frequent and imperative desire to move the bowels followed by explosive discharges of gas, blood and mucus: This symptom is usually spoken of as the diarrhœa of cancer. It is not in reality a diarrhœa in that fæces are rarely passed.

These are the classical symptoms which every gastro-enterologist should know. Other symptoms occasionally noted are an indefinite pelvic discomfort and pain or tenderness over the cæcum which has been mistaken for right-sided pathology.

DIAGNOSIS.—A patient presenting any one of the above symptoms should have a rectal and proctoscopic examination as a matter of routine. In our series of 491 cases, 56 per cent. of the tumors were within 7.5 cm. of the anus; 69 per cent. were within 10 cm. of the anus, and 31 per cent. were oral to this. It is quite evident, therefore, that more than a half were within

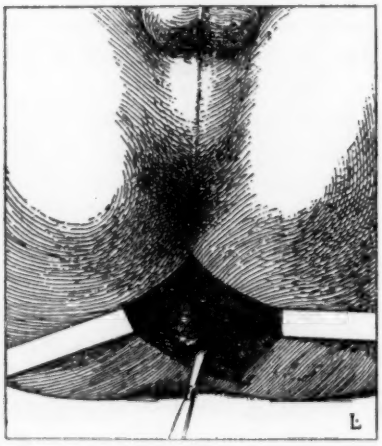

FIG. 2.—Illustrates the method of removing the coccyx.

reach of the finger, that two-thirds could have been diagnosed under anæsthesia by the finger, and that all except the sporadic cases in the colon could have been diagnosed by the proctoscope.

Duration of symptoms in this series was eight months. During this period many of the cardinal diagnostic symptoms already referred to had been present, so that at any time a diagnosis could have been made had the patient been examined.

Age.—In our series of 491 cases 4 per cent. were under thirty years of age; 7 per cent., thirty-five. According to the United States Bureau of Vital Statistics 5 per cent. of cases of rectal and colonic cancer were in children under nine years of age, 2.75 per cent. under nineteen years, proving that cancer is not confined to any age and that, while it occurs more frequently in middle life, still, for all, we must recognize the danger of placing too much importance on age.

A word must be said regarding the pernicious habit of biopsy for diagnosis. At the Symposium on Inoperable Cancer of the New York Academy of Medicine, Dr. Robert Abbe remarked that in the treatment of carcinoma by radium, the biopsy wound itself was one of the last to heal and was very stubborn.

TREATMENT.—*Operability.*—In our series of 491 cases extending over a period of nineteen years, 153 were considered inoperable. Of great importance is the history of the advance of our technic and a more liberal understanding of the possibilities. From a study of unexpected results in many so-called inoperable cases we are convinced that even in the late cases, except when the peritoneum is involved, there is always a fighting

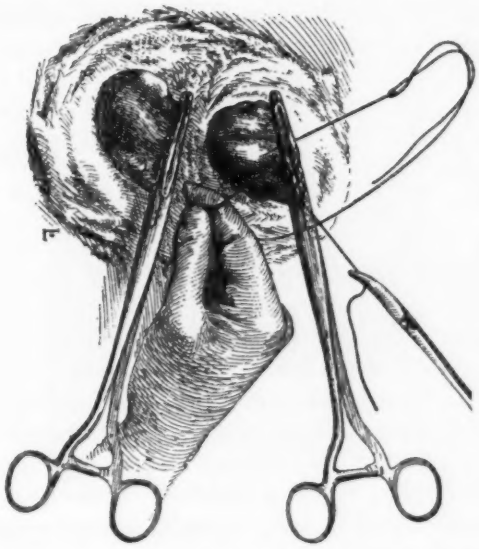

FIG. 3.—Illustrates the technic to be followed for dividing the bowel, when it is intended to leave the patient with a permanent colostomy and subsequently to remove the aboral portion of the sigmoid and the rectum.

chance. Of the 153 cases considered inoperable, none have been so classified because of the extent of involvement in the rectum itself.

Our operability for the total number is 60 per cent. This high percentage is due to the fact that Doctor Tuttle kept no record of inoperable cases. By operability is understood radical extirpation of the growth. In the past five years our operability has risen to 74 per cent. Let it be clearly understood that this refers to growths strictly localized in the rectum. As to the indications for radical treatment; when adjacent organs are involved our statistics show that we have often removed a part of the vagina, a part or whole of the prostate, seminal vesicles, urethra and uterus, several coils of intestine and part of the bladder. In many instances it is necessary to perform an exploratory laparotomy to determine whether the growth is operable.

Choice of Operation.—Operable cases: (1) Combined; (2) perineal; (3) abdominal.

We have performed the combined operation 111 times; in 36 of these cases it was performed in two stages. It is our operation of choice.

The perineal has been performed 102 times; the abdominal 20 times. Formerly we used the following operations now in disuse: Kraske, 20; modified bone flap, 32, and intrarectal, 18. When possible, for the psychical reasons already described, we always place the anus at the normal site. We prefer to perform the operation in one stage if it is possible, but, if necessary, we divide it into two stages.

The perineal operation is our operation of choice in very fat or in extremely debilitated people (Fig. 1). In all cases, as a matter of routine, we always remove the coccyx (Fig. 2). Preliminary colostomy is always done

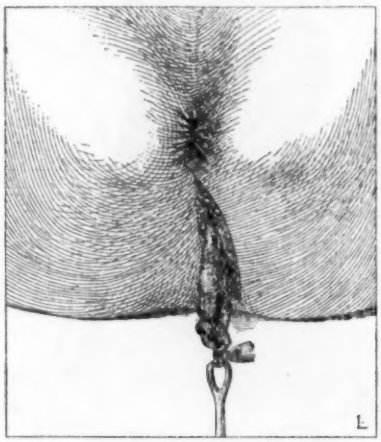

FIG. 4.—Illustrates the method of invaginating the proximal end of the aboral sigmoid and rectum.

when the growth is within 2 cm. of the anus, in order to prepare for the extensive removal *en bloc* necessitated by lymphatic involvement.

We have for some time abandoned rectal resection for the reason that in all of these cases the operation was followed by stricture. This is due to the presence of a terminal blood supply in the rectum rather than, as commonly supposed, to the absence of peritoneum. Exceptional work on dogs has been done by Barber which has confirmed us in this belief. It is the ischæmic rather than the peritoneal denudation that produces the stricture. It is axiomatic that the amount of scar tissue is in reverse ratio to the blood supply. This important contribution will form the basis of a subsequent paper.

Palliative Operative Treatment.—What can be done in this type of case is still of great importance. Until earlier diagnoses are made many cases will continue to fall in this class. If this paper served no other purpose than to convince the profession of the necessity of early colostomy in

inoperable carcinoma of the rectum it will have done some good. The fixed attitude toward colostomy is that it should be postponed until obstruction supervenes. This is certainly not in accord with the facts as we find them in 36 cases for cancer alone and in over one hundred for other conditions. It can be done, if necessary, under local anæsthetic.

What are the advantages of early colostomy in inoperable cancer as opposed to the supposed disadvantages? It reduces the inflammation, often converting an inoperable into an operable case. It obviates intestinal obstruction and its accompanying symptoms of pain, constant secretion and defecation, permits rest and sleep and insures recuperation. The patient renews his normal routine as to habits and diet. It stops hemorrhage. In short, it places the parts at surgical rest. If early it is without notable mortality; if late this rises to 40 or even 50 per cent.

Local Cauterization.—This is frequently of great value; it stops pain and limits secretion and odor. If frequently repeated it may keep a patient alive for many months.

Treatment by radio-active substances, fulguration and by biochemical derivatives is not here considered.

CONCLUSIONS

1. We would urge that digital and proctoscopic examinations be made routine in all patients presenting gastric or intestinal symptoms. If this is adapted a great many cases will be diagnosed early and saved.

2. That all cancer cases should be referred to a surgeon, as he is best fitted to pass judgment as to whether they are suitable for operation or not.

3. If inoperable, colostomy should be performed as soon as possible, thereby saving much suffering and discomfort.

4. That no patient should be denied a radical operation until it is proved beyond doubt that it is not justifiable.

5. That our technic is now more perfect and consequently we are saving many cases which previously died from shock and peritonitis.

CORRESPONDENCE

SKIN ASEPSIS IN SURGERY

EDITOR ANNALS OF SURGERY:

PROBABLY there is no detail on which the ultimate success of a surgical operation is more dependent than the employment of an efficient, but non-irritant, antiseptic for the sterilization of the operator's hands and the skin of the patient, and the maintenance of the latter in an aseptic state until physiological repair has taken place. The object of this communication is to invite attention to some personal deductions derived from an extended experience, and to pay tribute to the chemical—perchloride of mercury—which has, in and out of season, stood the test of the diverse experiments, modes, and whims incidental to three decades of hospital practice.

I. Perchloride of Mercury is the most reliable and least irritant antiseptic that I have, so far, met with for the sterilization of my hands. The routine is as follows: The nails are trimmed, and hands and arms scrubbed in a running stream of warm water, with soap and nail brush. They are then thoroughly washed in hot formalin lotion (15 c.c. of 40 per cent. solution to litre of water). Next immersed for a few minutes in alcoholic mercurial solution (Hydrarg. Perch. 1; acid tartarici 5; water 200; and alcohol 800). And finally are washed in acid mercurial lotion (Hydrarg. Perch. 1; acid tartarici 5; water 2000). The latter is repeated, when necessary, during the operation, and the full preparation is gone through irrespective of the use of gloves.

II. It is the most potent and, at the same time, the least noxious chemical for the sterilization of the skin, and while its primary effects usually endure until the wound is healed, it rarely causes any subsequent irritation in or around the operative field, and is comparatively guiltless, as a causative factor, in the production of that disconcerting legacy—post-operative intestinal adhesions. During the past year I have had so many cases returning, who had been operated on during the iodine epoch, presenting symptoms of chronic intestinal obstruction, that I feel convinced that disinfection of the skin of the abdomen by tincture of iodine is a most dangerous procedure, and I regret to have to state that, in some of my cases, it has proved itself to be a veritable death trap. I have observed one particular variety of adhesion constant in these cases—one or more dense strands of omentum which glue or suspend the transverse colon to the anterior parietal wall, and, frequently, underlying these bands, one encounters an adherent conglomerate of distorted coils of small intestine, the undoing of which is often a most laborious and exhaustive undertaking; how peristalsis ever overcomes such obstacles and how the foodstuff pirouettes through such a maze, only tends

to prove that the human body is endowed with a most remarkable margin for error.

I find this parlous condition particularly frequent after gastric operations, and common after appendicitis (I do not refer to adhesions in distal segment of ileum), and it induces symptoms which may readily be mistaken for a recrudescence of gastric ulceration, or raise a doubt as to the efficacy of excision in relieving the syndrome of a diseased appendix. As a matter of fact the last state of these unfortunate persons is often much worse than the first, in that they usually have the pangs and paroxysms of obstruction tacked on to their previous aches.

Such being my experience, I found it incumbent to forego the convenience and simplicity of the iodine method in abdominal work and to revert to my old formula, viz.: Shaving and scrubbing the field with soap and water, then washing with alcoholic mercurial solution, next applying a large square of sterilized lint wrung out in warm aqueous mercurial lotion, and retaining same in position by sterilized wool and bandage, until the following day, when it is removed on the operating table, and a final wash with alcoholic mercurial solution is given before the dry towels are applied to isolate the part.

III. Perchloride of mercury fomentations are the ideal dressing for septic wounds in that they keep the surrounding skin in good tone, and free of intruders while the fight is raging within. This is a most important consideration, and has not received the attention which it deserves. There is no chemical of equivalent potency comparable to Hyd. Perch. in this respect, as it rarely produces any eczema or other irritation, and never gives rise to any symptoms of absorption. Also it may be apropos to mention the well-known, but commonly ignored fact, that the continuous application of heat is of immense service in assisting the natural processes in the elimination of infection. Hot "perchloride" fomentations (1 in 3000), wrung dry, used in conjunction with three or four hourly irrigations of wound with hot peroxide hydrogen lotion (60–120 c.c. to a litre) followed instantly by hot carbolic lotion (15 c.c. to litre) is the best treatment for any desperate infected wound that I know of—if combined with the ordinary rudiments of surgery—free dependent drainage, removal of foreign bodies (which obviously includes all dead material), absolute rest and continuous out-door fresh air.

IV. Hot "perchloride" fomentations applied hourly, except when patient is asleep, is the most effective and rapid method of curing a carbuncle in debilitated subjects, *e.g.*, diabetics and nephritics, and renders the use of a knife unnecessary. For years it had been my practice to excise the back of necks and large segments of the dorsal regions, etc., but the severity of the procedure, in such subjects, and the length of time it took for those huge wounds to heal up, ultimately switched me on to the above method—which I have found to be constant in certainty of cure, and in the prevention of recurrence in adjoining area.

V. In the disease, furunculus, very prevalent in subtropical regions, lavage of the whole infected area, three times a day, with aqueous mercurial lotion, and the application—four hourly—of hot " perchloride " fomentations to the suppurating boils, is specific in its action.

VI. In conclusion, while it may appear that I hold a brief for " peroxide carbolic " irrigation of wounds, and " perchloride " application to the skin, I wish it to be distinctly understood that I only advocate their use in weak solution, as there is nothing more insensate than to mortify the flesh by chemicals at any time, much less at the moment when its resistance is sorely handicapped by infective germs and their products. But I do maintain that for septic wounds I know of no treatment equal to the above one—that is if healthy bright red granulations, prompt disappearance of toxic symptoms, early—but not sudden—cessation of purulent discharge and rapid healing is the criterion of merit.

JOHN O'CONOR, M.D.,
Senior Medical Officer of the British Hospital of Buenos Aires.

December 19, 1917.

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